

Borders, Endogenous Market Access and Growth*

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Abstract

We discuss the role of contracting impediments created by the existence of national borders on open economy growth. In a two-good neoclassical Ramsey growth model with lack of enforcement on international trade contracts we show that endogenous trading constraints with positive trade may arise on the transition path towards an open-economy steady state. These constraints may bind more severely low-income economies. Dynamic incentives to fulfill international contracts are easier to provide to high-income agents that have a stronger love-of-variety and investment motives to trade internationally. Investment in capital serves thus as a commitment device.

The extent of the impediments may render countries unable to engage in international exchange at all, in effect keeping them in a poverty trap. Countries with dissimilar initial capital per capita may converge to different steady states. Contracting problems in international exchange may block the channel through which, as many researchers believe, international trade affects growth by increasing investment rates.

The model provides a new explanation for the correlations observed in the data, for example that the trade/GDP ratio across countries is positively related with income per capita. Our model and its extensions add to the understanding of a number of puzzles (inter alia "the missing trade") in international economics. Using new data on trade credit in international transactions we provide correlations supporting the view that collection risks hinder international exchange. Policy implications stress the role of promoting contract enforcement and trade liberalization.

Keywords: trade, growth, limited commitment, borders, poverty trap.

JEL classification numbers: D86, F15, F34, F43, O16, O41.

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1 Introduction

National borders introduce a separation between judicial systems of countries causing potential enforcement problems of international contracts to arise. Counterparties might not be willing or able to commit to fulfill trade contracts as readily as they would in domestic transactions. International trade carries with itself contractual risks that might be idiosyncratic and uninsurable. The risk of the exporter is not getting paid; the risk of the importer is nondelivery, deficient quality or late arrival of goods. Across the border it may not be easy to verify the reliability of a counterparty or take into consideration all arising contingencies while writing contracts. All these contracting difficulties might also prevent granting trade credit to attract buyers. In short, the existence of borders hinders proper execution of contracts.¹ Questions arise about how this affects international exchange and allocations. Can contractual imperfections caused by the border have a qualitative effect through trade on growth? Can the ability to trade be income-dependent? Can we explain from a contracting point of view why the trade/GDP ratio of some countries is so high while that of others so low?

To study the aforementioned questions in more depth we need to modify the open-economy version of a one-sector one-good neoclassical model of growth stemming from Ramsey (1928). This is because in such a model international trade is indistinguishable from capital flows as the consumption good is the capital good as well. It counterfactually predicts massive capital flows into economies that are further from their steady state level of capital per capita relatively to others. Even when transaction costs, faulty government policies or imperfect contract enforcement that hinder exchange with foreigners are introduced, the growth process of such a one-good economy is qualitatively unchanged. The welfare of the agents may be lower and convergence to a steady state might take longer if free trade is unfeasible. If other fundamentals between economies are the same, there is no variation in the steady state level of capital per capita between countries (see Marcat and Marimon (1992) or Barro et al. (1995)). Moreover, at the steady states trade would only exist for consumption smoothing reasons. Unless the shocks that the economy experiences at the steady state are sufficiently higher than those experienced by the economy on its transition path (and assuming no borrowing is exercised to "jump" to the steady state per capita level) the fact that one observes most trade between the most developed economies (see the review by Helpman (1999)) cannot be explained.

In our setup, we allow international trade in final goods differentiated by origin to take place while (in order to focus) disallowing pure capital flows.² We justify this assumption by noting that developing countries may not produce the whole range of developed countries' goods. The benefits of a country from trade may stem in many respects from the fact that its inhabitants can consume more advanced products and import investment goods unobtainable in the domestic market in autarky. At the same time, locally produced goods may offer some characteristics of foreign products. To capture these considerations and remain as close as possible to the one-good growth models we analyze allocations that arise in a two-good economy with home goods and importables being imperfect substitutes in consumption and perfect substitutes in investment.³ We assume that the terms of trade that the small

¹Examples of contracting problems in international trade are given in the Appendix, Section A.2.

²Important future research would be to study the behavior of the current account. We speculate that allowing for intertemporal borrowing and lending might not change qualitatively our analysis. For example, in a nonstochastic version of the model of Albuquerque and Hopenhayn (2004) which characterizes optimal contracts in a bank-project manager relationship the introduction of the outside option that we analyze could cause that no contracts would be written between the principal and low-income agents.

³This holds regardless of the level of consumption or investment. Therefore, the marginal gain from international trade even at no international exchange is finite. This is not the first time that this is assumed in the international economics literature. Clarida (1990) shows the importance of breaking the Inada conditions on the utility functions for an existence of a stochastic steady state of an open economy with international borrowing.

open economy faces in the world markets cause that investment goods are cheaper for open economies to obtain. Therefore, in the world with no contracting frictions, trade leads agents to accumulate more capital relative to the autarkic steady state level.

We view each international trade relationship as having inherent contractual problems. We build the model on observing how international transactions are conducted. To model the effects of limited contract enforcement on international transactions, we assume that trade is sequential in the sense that there is a separation between the shipment and payment for goods. There is a borrowing element in each international transaction. We set up the model in a principal-agent framework, where the agent can be understood as a representative consumer-producer of her home country. The principal exports his goods first. Each period the agent faces a temptation to renege on paying back for her imports.⁴ This introduces a repeated ex-post moral hazard problem. We use a reputation mechanism to enable international exchange. The agent fulfills current period commitments for fear of being denied future trade and being confined to autarky forever on. No other punishment for contract noncompliance is available.⁵ The principal wants to be repaid and realizes that the agent from the small open economy might be willing to default despite the threat of punishment. Consequently, he might trade lower volumes with the small open economy than in the world without the contracting friction. Therefore trading constraints on the volume of exchange available to the agent can arise endogenously.⁶

Our analysis delivers the following results. The scope of international market access of our small open economy is endogenously determined. In our model (contrary to, for example, the result of Marcet and Marimon (1992)) there might be international exchange on the growth path even when the agent is unable to commit to fulfill contracts at all. The model can give rise to different, even nonmonotonic, patterns of openness (measured as the trade volume/production ratio) as a function of capital. It is the low-income countries that may become constrained in trade and be unable to exchange first-best volumes. On the other hand, it might be the case that as an economy obtains a capital per capita high enough, it faces no constraints on the optimal amount of trade that it wishes to exchange with the outside world. We thus overturn the neoclassical result that low-income economies engage heavily in exchange with the outside world. When constraints on trade bind, the growth of the small open economy is hindered relative to a world without frictions, because investment is more costly to the agent. Trade volume is increasing in the level of capital per capita,

⁴This can have a following decentralized interpretation. In a given economy there are agents that are either eternally specialized exporters or importers that trade with the outside world. Exporters always receive payment. Importers can default. Both types of agents trade with each other domestically. A question arises whether the agents could not send their goods first to the principal. To validate our assumptions, we note that the principal need not have the ability to commit either. Moreover, it might be the case that the agents may not be able to pay cash-in-advance on their purchases, for example because of a lack of a properly functioning domestic credit market. Another instance when our assumption is valid that is when the agent would be included in the production chain of the exporter. Then, to add value, she might need to obtain first some intermediate products from the exporter.

⁵This is assumed so that analytical results are obtainable. In extensions we assume some level of contract enforcement on international contracts (see Section 3.7). We perform simulations for this case and for a model with "weaker" punishments (for example, an exclusion of a debtor of only few periods from the market). These modifications do not change the results qualitatively (see Sections 3.9.2 and 3.9.3).

⁶In modeling we make other simplifying assumptions which do not invalidate the generality of our results.

We assume exogenous technological progress for simplicity, although some studies of the effects of trade on growth (for example Frankel and Romer (1999) and Coe et al. (1997)) claim that there is a statistically significant effect of trade on productivity.

We do not study a specific underlying trade model for two reasons. First, the scope of interest here is on the effects of limited contract enforcement on exchange and not on the factor content of trade. Second, most canonical trade models – the Ricardian, the Heckscher-Ohlin, the specific factor and the new trade theory models – are essentially static and there are many ways one could provide their dynamic versions. See for example Atkeson and Kehoe (2000), Cunat and Maffezzoli (2004), Deardorff (2001) and Findlay (1970) for the Heckscher-Ohlin model, chapter 6 of Grossman and Helpman (1991) for an endogenous growth model with monopolistic production or Burgstaller (1986) for the Ricardian model.

also when the constraints on trade are binding. As capital is accumulated, the constraints on international trade are loosened. It is easier for the principal to provide incentives to an agent with a higher income. This is because agents with higher capital have a stronger love-of-variety motive to trade and are also more dependent on obtaining investment goods from abroad. Capital investment serves thus as a commitment device – a productive cost that increases the value of international trade to the agent relative to her default option. An interesting result in our nonstochastic model is that any easing of constraints in the future – for example caused by a credible trade reform – allows for more trade today.

The central result of the paper is that a multiplicity of steady states may occur. Countries with dissimilar levels of initial capital per capita may converge to different steady state capital per capita values. An economy may either be confined to autarky (when its capital per capita is low enough) or participate in international trade forever. In effect, we might have three groups of countries: those remaining in autarky, those trading a constrained, positive volume of trade, and those unconstrained in international exchange. In an extreme case, no trade may be possible with the outside world for any initial capital per capita value. Even with only one steady state of the system, contrary to the results obtained in a canonical one-good open Ramsey economy, capital per capita values corresponding to steady states with positive international trade might be influenced by binding constraints on trade.

In effect, we present a Ramsey growth economy with an infinitely-lived representative agent and poverty traps arising using a mechanism new to the poverty trap literature (see e.g. a survey in Azariadis and Stachurski (2004)). Limited commitment on contracts introduces incentive compatibility constraints to the agent's optimization problem. The nature of the punishment technology and the fact that it is easier to dynamically provide incentives to perform on contracts to a high-income agent may render the set of feasible sequences available to the agent nonconvex. Binding trading constraints affect the programming problem of the agent similarly to the effect of nonconvexities in technology already known in the literature. Whenever constraints on trade bind, an agent with an endowment far away from the open economy steady state capital per capita levels may not obtain full benefits of international exchange and increase her return on capital to the open-economy first-best levels. In fact, whenever the parameters are set so that multiple steady states are present, the agent is not willing to accumulate enough capital (although she could) to become credible to outside traders and start international exchange.

Our result is important, because it shows how the beneficial influence of international trade on growth through raising physical rates of investment that many researchers indicate (see Wacziarg and Welch (2003) for a discussion) may break down because of the inability to contract. It is exactly the low-income countries that might need international trade and investment goods (possibly with embodied technology) in order to develop. The contract enforcement problem in international transactions may be there regardless of the strength of the local contract enforcement institutions (although, of course, the domestic institutional setup may be a development problem of its own). It is the existence of the limited commitment associated with the border itself that causes the contractual problem. One may find a trade contract between the U.S. and France as hard to enforce as that between countries in Sub-Saharan Africa, especially for contracts written between small companies. Collection between countries with different domestic institutions may be hindered to the same extent due to the lack of a centralized enforcer.

Our model can also be interpreted as an international lending model with within-period noncontingent debt contracts. With our framework we are able to sidestep the Bulow and Rogoff (1989) critique of reputational punishment in debt contracts and resuscitate borrowing and lending on the growth path from capital per capita levels below the steady state ones. This is not possible for example in the Marcat and Marimon (1992) model where no exchange in a nonstochastic setup occurs since the agent would always be able to obtain a rate of return at least as high as the international market rate of interest on the amount she would have to

repay. The agent in our small open economy is unable to replicate the stream of allocations offered by the lender upon default because she is shut off from international trade and cannot obtain the importable. Market exclusion in the hands of international traders is a powerful punishment tool that supports the reputational argument for lending.

Our framework adds to the understanding of the border effect puzzle first indicated by McCallum (1996) where empirical evidence was provided that there is a great deal of "missing" trade between Canada and the U.S.⁷ It is in line with the work of Anderson (2000), Anderson and van Wincoop (2001, 2004), Anderson and Young (2002) as well as the empirical investigation in Anderson and Marcouiller (2002) that stresses contractual impediments to international trade in static settings. Our model may replicate the stylized facts that low-income countries trade less than others (see the survey in Baldwin (2003)). The correlation of the trade to GDP ratio and the level of GDP per capita in PPP terms across countries is positive in different samples and across time (see an example in Figure 3). In addition, the contract terms in trade pertaining to enforcement issues (maximum duration of trade credit on forfeiting⁸ contracts) and openness are correlated (Figure 4). In the years with available data, countries in which counterparties obtain better contract terms trade more than the others in relation to their GDP per capita. This measure is also highly correlated with income per capita. This indicates that there might be a link between income per capita, creditworthiness and trade volume – as posited in this paper. By endogenizing international market access we can obtain the patterns observed in both figures: economies with higher capital per capita may be inherently more open and an average company from a higher income country can obtain better terms on trade contracts.⁹ In the estimation results of gravity equations that we present in Section 4 both the importer's income per capita and our new measure of contract terms on trade transactions enter significantly as regressors of our measure of openness. We find that a 1% improvement in the length of trade credit of an importing country increases imports normalized by the GDP of the counterparties by 0.15%.

We make an important distinction between the effects of contractual impediments in trade that we discuss and the iceberg trade costs that Obstfeld and Rogoff (2000) propose after Samuelson (1954) to explain important puzzles in international economics. The iceberg trade costs will not easily validate the aforementioned correlations without introducing other imperfections. Lack of contract enforcement cannot be parametrized as a transaction cost in the way Stigler (1967) stipulated market imperfections could be, since it may change the properties of the equilibrium. In any case, the existence of the iceberg trade costs can exacerbate the contracting problem by lowering the gains from trade. With the same iceberg costs in trade, we can have countries that have totally different trade/GDP ratios due to the

⁷Fidrmuc and Fidrmuc (2000) show that the border effect was stronger for countries that were established after the disintegration of USSR, Yugoslavia and Czechoslovakia in the early 1990s. This may be some evidence that the border effect is more severe in economies that have lower income per capita than U.S. and Canada.

⁸The definition of forfeiting is given in Section A.1.

⁹As far as the level of real interest rates or interest rate spreads influence the volume of trade credit, there is a strong negative correlation between openness and these two measures in the same data used here. Of course, this may be also due to many other factors that are beyond the interest and capacity of this paper – monetary and exchange rate policy, banking concentration, etc.

Both correlations presented in Figures 3 and 4 may reflect a common cause – for example differences in institutions or geography. A series of papers which recently discussed the empirical relationship between trade, institutions and growth include Acemoglu et al. (2001), Acemoglu et al. (2002), Clague et al. (1999), Dollar and Kraay (2003), McArthur and Sachs (2000) and Rigobon and Rodrik (2004). Those stressing geography include inter alia Frankel and Romer (1999), Easterly and Levine (2002) and McArthur and Sachs (2000). Institutions are endogenous in each country and therefore need to be modeled. We do not provide such a framework here. We can interpret limited contract enforcement however as a part of the institutional setup of an economy. As for geography, when we control for geographical factors such as landlockedness or being an island, the discussed correlations still hold. The openness-GDP correlation may also be explained by using some known trade models with modifications – for example by a dynamic Heckscher-Ohlin model with capital accumulation with a nontradable sector that is most labor-intensive among sectors. But still then the fact that traders from low-income economies are also the ones which appear to have larger contractual impediments to trade is not explained.

incentive problems in international contracting.

The policy implications of our work stress strengthening contract enforcement. Foreign counterparties in developing economies need to enjoy the same (high) level of protection from contract noncompliance as domestic entities. The problem may be, however, that marginal increases in contract enforcement may not remove the constraints on international exchange and lift a country out of a poverty trap. We also underline the importance of trade liberalization. Removing trade barriers increases the incentives individuals have to perform on international trade contracts. Inducing foreign direct investment that could substitute contracts between unrelated counterparties by intra-firm transactions might be another way of overcoming the constraints on international exchange. Developed countries' export credit agencies or international organizations such as the IMF can play an important role in extending trade credit to a developing country especially in times of financial distress and thus easing the contractual difficulties in international trade.

The intuition for our results comes from the fact that agents from an economy better endowed with capital have a higher incentive to trade with the outside world. It will occur in any trade model where importable prices relative to consumables fall with capital accumulation. For example this happens in a two-factor three-sector dynamic Ricardian model with a labor-intensive nontradable and when utility and capital accumulation functions are homothetic in all goods.¹⁰ This may happen in the real world for many other reasons. First of all, high-income economies might produce more complex goods. This may require more international cooperation. Firms from such economies might also find it beneficial to out-source labor-intensive production to other countries and reap the bulk of the arising benefits. Viewed from another angle, richer countries tend to have better contract enforcement systems that increase the enforceability of international contracts. Good institutions might take time to be built and be costly. There might be scale effects present in institution building. The effect can also be delivered by an initial fixed cost that needs to be borne to start trading – such as a construction of a container port or proper road infrastructure. The particular mechanism that delivers the results in our model – that richer agents have a stronger love-of-variety driven incentive to trade – may be only one of the processes that actually occur. In the model the more of the home good is produced the more there is to gain through diversifying consumption as the marginal utility of the home good decreases. We could also offer a firm-based interpretation of our mechanism using unobserved product quality (in the short run).¹¹ In all interpretations we require the value of keeping reputation for the studied agents to increase with their income.

Literature Review

Relating our model to the literature we note that we achieve a possible poverty trap differently from previous models known in the literature and escape thus the classification undertaken by Hoff and Stiglitz (1999) who associate a poverty trap with coordination failures. Matsuyama (2004) provides a general equilibrium overlapping generations model with a poverty trap caused by frictions in capital markets where agents cannot commit on repaying on investment contracts. With the same level of frictions in the capital market in two countries, interest rates are lower in the country with lower capital per capita. As capital markets

¹⁰Upon request the author can provide an extension of the basic deterministic model to the aforementioned framework. We can show that a derivation of a modified version of Proposition 5 of the current paper and that multiple steady states may occur. The curse of dimensionality and the complexity of the theoretical analysis preclude us from giving a fuller account of that economy.

¹¹The consumer-producer of our model can be reinterpreted as a firm facing revenue functions strictly concave enough in quantity for its products in home and foreign markets that solves a revenue maximization problem with firm-specific capital accumulation. As the specific capital is increased, the firm is more willing to produce high quality goods and not default on quality to pursue short-term gains from impunity in the foreign market. With this interpretation, firms with higher capital stock are willing to export more and low-capital ones might be barred from exporting.

are opened, capital flows out of low-income countries in the search for a higher return. In our model, there is no friction in the domestic markets – we abstain from the role of domestic institutions and capital markets on international exchange. The poverty trap that occurs stems from the way everyday transactions are conducted. It is solely the friction associated with the border that bites in our model. In a sense, the borrowing constraint in our economy is endogenously determined. Even with no enforcement in international exchange, the agent may still trade in our economy, although in Matsuyama’s environment it is impossible. Our results hold in a setup with infinitely-lived agents. His framework should be regarded as complementary to ours.¹²

Our model falls into the strand of research on international debt problems.¹³ Models that are closest to ours include the work of Marcet and Marimon (1992). These authors analyzed *inter alia* a one-good Ramsey growth economy with frictions in international borrowing. Agents in a small open economy were unable to commit credibly to repay the loans that they would undertake. As a result, the economy in question resembled in simulations a closed economy, grew slower than an open economy without the friction, and borrowing was possible only in the neighborhood of the steady state for consumption smoothing reasons. This was because the Bulow and Rogoff (1989) intuition worked: agents with capital far from the steady state value would default on any commitments, being able to derive higher gains from home investment after default. Therefore, in a deterministic setting there would be no lending in the Marcet and Marimon’s economy since there is no incentive mechanism that can prevent agents from defaulting. Kehoe and Levine (1993) provide a general equilibrium treatment of enforcement problems in an endowment economy with complete markets and debt constraints. The agents can possess an inalienable private endowment which cannot be taken away from them and assets which can change hands. The penalty that can be applied on agents entails exclusion from intertemporal and interstate trade, but not from the spot markets. In effect the welfare theorems may not hold and the equilibrium may fail to exist. A model with two goods is provided by Arellano (2003) where an endowment economy with tradable and nontradable goods and noncontingent insurance contracts paying off in the tradable good is analyzed. The difference of our model from these papers is that we explicitly analyze a growth economy with two goods, its steady states and how market access can depend on what Kehoe and Levine would label “private” endowment. The penalty for noncompliance on contracts involves a restriction on future trade which affects the achievable steady state capital per capita levels of the economy. In our production economy the penalty structure is different from that in Kehoe and Levine, involving total market exclusion. As economies are endowed with more capital per capita, they also become more interdependent with the outside world and the threat of exclusion is more painful to them.

Our work is also closely related to the analysis of principal-agent optimal contracts in dynamic lending and investment under limited commitment setup by Thomas and Worrall (1994) and Albuquerque and Hopenhayn (2004). In both papers the agent can produce a divisible amount of some good with the funds acquired from the lender. Thomas and Worrall (1994) study a firm investing in a country when there is a possibility of expropriation. Both the firm and the country can renege on the contract and the starting size of the loan at

¹²In our framework, it is also not the non-concavity of the production function (see Dasgupta (1997)), threshold capital requirements to overcome fixed costs, savings or demographic traps as presented in Sachs et al. (2004), nor an overlapping generations framework with exogenously specified savings functions as in Galor (1996) or Deardorff (2001) that create the trap. The steady state difference in incomes between countries may also not be due to specialization in trade in the dynamic Heckscher-Ohlin models with one reproducible factor which share the property that accumulation ends when the factor price equalization set is achieved (Atkeson and Kehoe (2000), Cunat and Maffezzoli (2004)). Neither are we concerned with hyperbolic discounting and problems of self-control as in Bernheim et al. (1999) that can render individuals unable to enrich themselves. We obtain a poverty trap in a Ramsey neoclassical growth model with endogenously determined savings where a contracting impediment may lead to nonconvexities.

¹³See for example Atkeson (1991), Cole and Kehoe (1995), Eaton and Gersovitz (1981), Kehoe and Perri (2002), Kletzer and Wright (2000) or Kocherlakota (1996).

the optimal level of investment is non-enforceable. The optimal contract has a backloading property: loans increase in size over time and following good productivity shocks, but the host country does not receive any payments until the optimal amount of investment is reached. This way the lender is repaid on the transition path to the efficient loan size while the agent obtains credible promises of higher future utility. The authors also study a situation in which there is capital accumulation to the project (that is, investment depreciates slowly once it is made) which in general may lower the attainable investment level. Albuquerque and Hopenhayn (2004) built on this model while analyzing a lending relationship where the borrower can unilaterally default on the loan and extend the basic result by exploring more general outside option values for the borrower. They study a model in which there might be a need of some initial fixed investment that cannot be overcome by the agent himself. The profits could be reinvested by the agent. In their model if the agent possesses initial capital so that he can pay the initial setup cost, no lending agreement between the parties is needed: the principal cannot improve the utility of the agent without a loss.

Our framework is different from both of these papers, and so is the scope of our attention. We analyze an optimal principal-agent type of contract under balanced trade. We study a risk-averse agent that can self-finance her initial investment (which is productive) in a two-good model. The outside option in our model – the value of autarky in a growth framework – does not conform with the assumptions in Albuquerque and Hopenhayn (2004) and renders their contracts not incentive compatible (the outside option for the agent can give a higher utility than the amount of a loan advanced each period). There is no liquidation value in our model and there is no collateral to be seized. In both of these papers, if one allowed the recipient country or the borrower respectively to accumulate capital on their own starting with some initial nonzero level of capital, there is no reason for lending at the efficient level of investment in a deterministic economy, and agents can obtain the efficient level of capital on their own. In our model, once the trade relationship is destroyed, the optimal (from the agent's point of view) level of investment in the economy declines. The similarity between our models is in the fact that no contract might be offered to the agents in need and profitable matches may not be exploited because of the contracting problem. We also have a property that is similar to the increasing loan size in their models: trade volume strictly increases with capital endowment on the range where it is positive. Thomas and Worrall's analysis with capital accumulation precedes our result that the steady state capital value in the Ramsey model can depend on the extent of the contracting problem. Expanding the space of contracts beyond these with balanced trade is clearly necessary when one would wish to study the current account dynamics or lending to a country by an outside organization such as the IMF or the World Bank.

There exist models with asymmetric information where the ability to borrow depends on one's own endowment relative to the outside world. An example of such is Gertler and Rogoff (1990) where contractibility is assumed and informational aspects (hidden information on investment decisions) play a role. The possibility of saving (a part of) the loan in the outside financial markets causes an impediment to lending as in Bulow and Rogoff (1989). Once ex-post moral hazard is allowed, however, no lending is possible there in a static setting. We need to structure long-run incentives to provide contractibility to such transactions. Contrary to our model, there would always be one steady state if one allowed for capital accumulation. The volume of lending/GDP predicted by their model is hump-shaped since the funding requirements decline with the size of the capital on hand. We obtain different patterns of trade openness, depending on the strength of the contracting problem. Boyd and Smith (1997) provide a two-country model where a costly state verification problem leads to unequal growth of economies with unequal initial capital endowments.

There is a wide literature on the effect of imperfect contract enforcement on trade that looks mainly at static frameworks. Anderson and Young (2000, 2002) study how incomplete contracts in an international setting require intermediation by some superior enforcers (mo-

nopolists with matching technologies or better enforcement) and that imperfect enforcement might be deliberately chosen by the weaker sides of the market to capture some of the surplus created by trade in an endowment economy. Anderson and Marcouiller (2005) provide a static general equilibrium Ricardian model of trade with endogenous predation where agents play a noncooperative game in choosing their occupations. The possibility of predation allows the agents from the poorer economy to tilt the terms of trade into their favor. The parameters that govern the system include the predation and evasion technologies. Levchenko (2003) and Antras (2003) study the impact of capital market imperfections on the pattern of trade. An early model of this sort is provided by Bardhan and Kletzer (1987). In contrast to this avenue of work, we study the implications of contractual problems on trade volume in a dynamic setting. An extension to study the important questions of trade patterns and contract enforcement is clearly desirable.

The paper is organized as follows. In Section 2 we present the model. Section 3 characterizes optimal allocations and presents simulations. In Section 4 we discuss the correlations that exist in the data and reconcile them with our model. Section 5 concludes. Examples, proofs, figures and tables are relegated to the Appendix.

2 The model

2.1 Environment and preferences

A small open economy (further SOE) wishes to trade with the rest of the world. Time is discrete. There is perfect information in the model and this is common knowledge. It is populated by an infinitely lived representative consumer-producer which we shall call the agent. Her period utility function is additively separable in a home-produced good X and an importable Y :

$$u(c_t^x, c_t^y) = u(c_t^x) + u(c_t^y) \quad (1)$$

where c_t^x and c_t^y denote the consumption of the goods X and Y respectively at time t . We also impose the conditions $u'(c) \geq 0$ and $u''(c) \leq 0$ and that marginal utility of consumption of any good at zero units is not infinite ($0 < \lim_{c \rightarrow 0} u'(c) < \infty$).¹⁴ We make the assumption that $u(0) = 0$. An example of a component utility function that satisfies our assumptions is a transformed Stone-Geary utility function with $u(c) = \ln(c + 1)$. The agent discounts future utility with a discount factor $\beta < 1$.

A risk-neutral principal resides outside the small open economy.

2.2 Production and investment

The agent in the economy has a neoclassical production function of the home good

$$X_t = X(K_t, L_t) \quad (2)$$

with capital K_t and labor L_t as the factors of production. The production function satisfies the Inada conditions in both factors, $\lim_{K_t \rightarrow 0} X_K(K_t, L_t) = \infty$, $\lim_{K_t \rightarrow \infty} X_K(K_t, L_t) = 0$, $\lim_{L_t \rightarrow 0} X_L(K_t, L_t) = \infty$ and $\lim_{L_t \rightarrow \infty} X_L(K_t, L_t) = 0$. The agent's initial capital at time 0 is $K_0 > 0$. She supplies inelastically one unit of labor. In the remainder of the paper we shall work with the production function in per capita terms (in the intensive form) $x_t = f(k_t)$ and capital per capita k_t .

¹⁴Thus we break the Inada condition on the utility function. The properties of the neoclassical production function guarantee the existence of a nontrivial steady state. With the Inada condition holding, one could always provide incentives for agents to trade. To make the analysis interesting, we drop this assumption.

Our assumptions on preferences do not mean that we cannot have homothetic utility in general; the commonly used CES functions, however, do not conform to our assumptions except for the linear case.

The investment sector produces capital with a technology using either good X or Y (call the amounts of the goods it uses respectively I_t^x and I_t^y). Net investment is linear in home and foreign goods and accrues according to

$$I_t = I_t^x + I_t^y \quad (3)$$

Capital depreciates at a rate $\delta > 0$ per period. Capital, once invested, cannot be consumed.^{15,16}

The production framework is summarized in Figure 1.

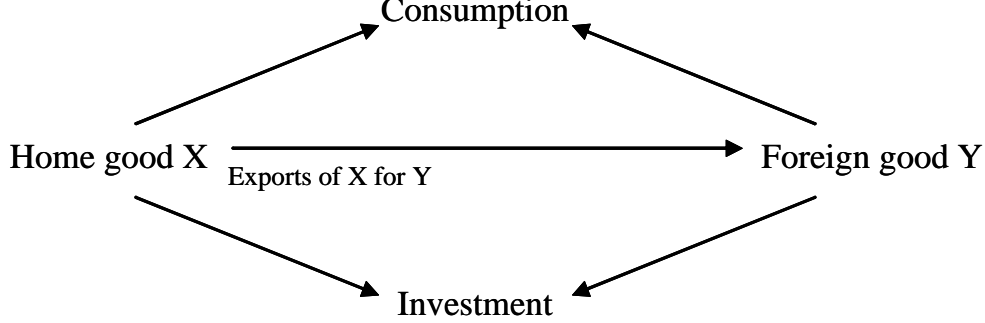


Figure 1: Production, consumption and investment.

2.3 International trade

To be able to consume the foreign good Y the agent must export her own produce X and import good Y from abroad. Let $p_t = \frac{p_{x,t}}{p_{y,t}}$ denote the relative world market price of a unit of a good X in terms of a unit of good Y at time t . The economy in question is small with regard to the outside world, so that the decisions of the representative agent do not affect the world market price. Denote by z_t the volume of exports in period t . In each period trade is balanced so that the agent imports $p z_t$ units of good Y . We constrain the world market price from above so that at a steady state both goods would be consumed when there are no impediments to trade.¹⁷

Since there is no money or banking system in our setup, we model the limited commitment on contracts in international trade in the following way. We set up a principal-agent problem. Within each period trade is sequential, i.e. the principal first ships his goods and then waits for the reciprocal physical shipment from the agent.¹⁸ Thus we assume that instantaneous

¹⁵This assumption is made to outrule pathological consumption-savings avenues.

¹⁶Another approach one could follow is to use the production framework suggested in Backus et al. (1995). The foreign goods are used there as intermediate goods to produce a nontradable final good out of which consumption and investment are undertaken. The basic result of Proposition 5 is upheld when we alter the final good production technology to have a finite marginal product of each intermediate input. Unfortunately this gives less intuitive conditions and trades one group of complexities for another. Simulations that were carried out for this framework conform with our basic results. The findings are available from the author upon request.

¹⁷The condition for this is $pu'(pz^* - I^{y*}) \leq u'(0)$, where the starred values denote steady state values of variables.

In what follows we shall be interested in the case when $p \geq 1$ so that imports are more attractive to consume and invest by the agents of the home country. Alternatively, we could introduce a love-of-variety investment function.

¹⁸This corresponds to the way many international transactions occur: the shipment of the goods precedes the payment. See Section A.2 for examples of contracting problems in international exchange.

exchange – barter directly between the counterparties at the borders – is impossible and that there is a credit element in each international transaction. The fulfillment of the contract cannot be enforced at all. The principal supplies the good at world prices earning zero profits from the relationship.¹⁹

We assume that imports into the economy in question take place first. This means that the agent in the SOE is effectively a borrower. She can choose to default on her obligation to export goods in return for the obtained credit. We assume that if the counterparty defaults on its obligations it will be punished with market exclusion – a grim trigger strategy – and will be denied trade in the future in the outside world. This penalty is the harshest the outside world trader can exercise. We make these assumptions for tractability reasons and to show that our results carry through in these polar cases. Since there is no other penalty available to the principal, trade can be sustained only by an implicit promise of future continuation of exchange.²⁰

2.4 Timing of events

The intra-period timing of events in the SOE is as follows. The agent – the consumer-producer – uses her capital to produce the home good. Then, a contracted amount of the importable arrives from abroad. The agent makes the decision whether to fulfill the export contract, which is the payment for the importable, or not. Finally, the consumption-investment decision is made. The next period ensues. This is summarized in Figure 2.

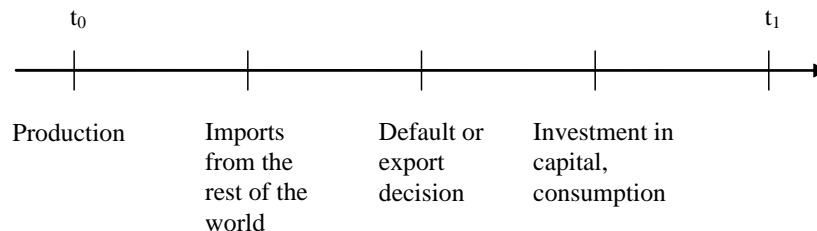


Figure 2: Timing of intraperiod events of the model.

The symbols t_0 and t_1 denote subsequent periods.

¹⁹In what follows we assume that the principal offers the level of imports to the agent at the maximum amount that does not make the agent default. In effect we analyze the allocations of the most efficient equilibrium.

²⁰The assumption of no enforcement of contracts greatly simplifies the proofs. The addition of partial enforcement in the model does not change qualitative results. See the discussion in Section 3.7.

At the cost of complicating the model, we could introduce imperfect contract enforcement on the side of all counterparties. Then, we could assume a randomizing device that would choose each period which counterparty has to ship their goods first and become the creditor in the trading relationship. We could also think about two identical small economies which are taking turns in being the importer and exporter.

Instead of the grim trigger punishment, we could use for example the punishment strategy of the forgiving trigger, i.e. a rule that the agent could return to international trade after some prespecified T periods. In such a case the contracting problem would be more pronounced because the agent would have weaker incentives to perform on the contract. See Section 3.9.3 for details.

In general the individuals could also suffer an internal penalty after they default on outside contract along the lines of the work of Cole and Kehoe (1995).

2.5 Example in an endowment economy

We can offer intuition for our results in the following endowment economy. Suppose that the utility function of an agent is given by $u(c_t^x, c_t^y) = \ln(c_t^x + 1) + \ln(c_t^y + 1)$ where c_t^x and c_t^y denote consumption of the home endowment good and the importable and that the world price is $p_t = p > 1, \forall t$. Assume that the agent receives each period a constant endowment x of the home good X . Denote by z the amount of good X traded by the agent.

The Incentive Compatibility (IC) constraint for a representative agent in this economy can be written as

$$[\ln(x - z + 1) + \ln(pz + 1)] \frac{1}{1 - \beta} \geq [\ln(x + 1) + \ln(pz + 1)] + \ln(x + 1) \frac{\beta}{1 - \beta} \quad (4)$$

The left hand side of the inequality represents the discounted utility from trading forever whereas the right-hand side shows the utility that the agent can get from defaulting. To investigate when an agent would default on any amount of trade, we differentiate both sides of (4) by z . Taking the derivative at $z = 0$ (no trade) one can see that for trade to occur it must be the case that the endowment must be at least as great as some \underline{x} that satisfies

$$\underline{x} = \frac{2 - \beta - p}{(\beta + p - 1)}$$

Moreover, for any $z > 0$ at \underline{x} the condition is violated because the derivative of the default option increases faster with z than that of complying and continuing with trade. We can also say that if $p = 1, \exists \underline{x}: (x \leq \underline{x}) \Rightarrow (z = 0), \forall \beta \in (0, 1)$. The property follows from the fact that one can always find an endowment low enough so that the marginal utility of consumption of the home good is higher than the discounted value of the marginal utility of the importable that is gained through exchange.

This means that agents with low endowment would like to default if they were allowed to trade. The love-of-variety motive to trade is stronger for agents with higher endowments. An example of the value functions of the agent in an endowment economy is shown in Figure 5. Armed with the intuition from the endowment economy, we turn next to the layout of the model with production and to the characterization of allocations.

3 Allocations

In characterizing the economy, we use dynamic programming methods developed in Rustichini (1998a, 1998b) when incentive constraints are present. We model the agent as choosing sequences of trade volumes and investment under the requirement that they do not default on the repayments to the principal. In effect this will give us the characterization of the most efficient equilibrium that offers the entire surplus to the agent and would be chosen by the principal at time t_0 while dealing with an agent with initial capital k_0 .

Before we discuss the full programming problem, we characterize two polar situations, one in which the agent can trade frictionlessly with the outside world and one in which she is confined to autarky. The utility one can obtain under the first best problem provides the "maximum prize" the agent can receive to fulfill her commitments whereas the latter will provide the punishment offering the lowest utility possible – the stick to perform in sequential trade.

All proofs are relegated to the Appendix, Section A.3.

3.1 The first best optimization problem

When the agent from the SOE can engage in international trade with perfect enforcement across borders we can write the consumption-savings problem of the representative agent in the SOE as

Problem 1a

$$V^*(k_0) = \sup_{\{(z_t, I_t^x, I_t^y)\}_{t=0}^\infty} \left(\sum_{t=0}^\infty \beta^t (u(c_t^x) + u(c_t^y)) \right) \quad (5)$$

subject to

$$\begin{aligned} & \text{(state equation)} \quad k_{t+1} = (1 - \delta) k_t + I_t \\ & \text{(investment equation)} \quad I_t = I_t^x + I_t^y \\ & \text{(consumption of good } X) \quad c_t^x = f(k_t) - z_t - I_t^x \\ & \text{(consumption of good } Y) \quad c_t^y = pz_t - I_t^y \\ & \text{(nonnegativity constraints)} \quad 0 \leq c_t^x, 0 \leq c_t^y, 0 \leq I_t^x, 0 \leq I_t^y, 0 \leq z_t \\ & k_0 > 0 \text{ given.} \end{aligned}$$

The return functions are bounded above and below because of feasibility constraints and the action spaces are nonempty and compact. By Theorem 4.2 in Stokey and Lucas (1989) there is a corresponding functional equation to this problem. By Theorem 4.6 of Stokey and Lucas (1989) the value function exists and is unique.

The corresponding functional equation is, with substitutions for c_t^x and c_t^y made,

$$V(k) = \max_{I^x, I^y, z} (u(f(k) - z - I^x) + u(pz - I^y)) + \beta V(k') \quad (6)$$

subject to

$$\begin{aligned} & \text{(state equation)} \quad k' = (1 - \delta) k + I^x + I^y \\ & 0 \leq c^x, 0 \leq c^y, 0 \leq I^x, 0 \leq I^y, 0 \leq z. \end{aligned}$$

We can define the feasibility correspondence as $\Gamma_{ft}(k) = \{k' : k' \leq (1 - \delta)k + pf(k)\}$.

Let us gather the properties of this function $V(k)$.

Proposition 1 $V(k)$ is increasing, strictly concave and differentiable almost everywhere in k .

Notice that if $p > 1$ then the agent in the economy in question would like to rely totally on the imported good to finance investment. One can see that in the steady state defined by a capital per capita at which investment would be equal to depreciation of the capital stock there would be $I^x = 0$ because, through exporting the same amount, one could obtain pI^x , which could be divided between consumption of the imported good and investments. In such a case $I^x > 0$ only if the constraints on the volume of trade bind; otherwise investing from domestic product would be dominated. From the first-order conditions it must be the case that $u'(c^x) = pu'(c^y)$. Denote by k^{***} the steady state capital per capita level in the no frictions economy.

The behavior of the trade volume $z(k)$ and the trade/production ratio $\frac{z(k)}{f(k)}$ depends on the utility and production functions and the world price. For utility functions of the CARA and $u(c) = \log(c + d)$ (with d as a constant) classes in each consumption good, $z(k)$ is increasing in k whereas $\frac{z(k)}{f(k)}$ is decreasing in k from an initial trade/production ratio of one. In the first-best world the trade volume/GDP would decrease with capital. This is driven by investment demand. With no investment outlays, the trade/GDP ratio would be flat.

3.2 The optimization problem in autarky

The agent in the SOE might be confined to autarky when no one from the outside world wishes to trade with him (either because he is being punished or because he would default on any possible trade volume). Then, he solves the following problem

Problem 1b

$$W^*(k_0) = \sup_{\{c_t\}_{t=0}^\infty} \left(\sum_{t=0}^\infty \beta^t u(c_t) \right) \quad (7)$$

subject to

(state equation) $k_{t+1} = (1 - \delta) k_t + f(k_t) - c_t$
(consumption of the home good) $c_t \geq 0$
 $k_0 > 0$ given.

The set $\Gamma(k_t) = \{k_{t+1} : k_{t+1} \leq (1 - \delta) k_t + f(k_t) - c_t\}$ is convex and compact and $u(c_t)$ is a concave function. The restriction that we have on the feasible next-period capital $k_{t+1} \in \Gamma(k_t)$ ensures that our returns are bounded. By Theorem 4.2 of Stokey and Lucas (1989) there is a functional equation $W(k)$ that corresponds to the sequential problem. All the Blackwell conditions needed for a contraction hold. Using Theorem 4.6 of Stokey and Lucas (1989) there is a unique value function of the problem. The value function is continuous and strictly concave and differentiable almost everywhere by standard results of dynamic programming. We denote by k^* the autarky steady state capital level.

3.3 The optimization problem with limited commitment in international trade

With the posited friction in international trade, *Problem 1* has to be augmented by a non-default trading constraint. The principal will not allow the agent to borrow more through trade than what she is willing to repay. Incentive compatibility constraints for the agent (IC) that need to be respected are required to be added to the problem.

Each period the agent faces an infinity of such incentive constraints.²¹ This is because the consumption plan chosen by the agent has to be incentive compatible at any time in the future. Taking into consideration that the agents make the investment-consumption decision following default or repayment we can state

Problem 2

$$U^*(k_0) = \sup_{\{(z_t, I_t^x, I_t^y)\}_{t=0}^{\infty}} \left(\sum_{t=0}^{\infty} \beta^t (u(c_t^x) + u(c_t^y)) \right) \quad (8)$$

subject to

$$\begin{aligned} k_{t+1} &= (1 - \delta) k_t + I_t \\ I_t &= I_t^x + I_t^y \\ c_t^x &= f(k_t) - z_t - I_t^x \\ c_t^y &= pz_t - I_t^y \\ 0 &\leq c_t^y, 0 \leq c_t^x, 0 \leq z_t, 0 \leq I_t^x, 0 \leq I_t^y, \\ k_0 &> 0 \text{ given, and an incentive compatibility constraint (IC), } \forall t \geq 0: \end{aligned}$$

$$\begin{aligned} &\sup_{\{(z_i, I_i^x, I_i^y)\}_{i=t}^{\infty}} \sum_{i=t}^{\infty} \beta^i (u(c_i^x) + u(c_i^y)) \\ &\geq \sup_{(k_{t+1}, I_t^{y,d})} \left(u(f(k_t) - I_t^{x,d}) + u(pz_t - I_t^{y,d}) + \beta W(k_{t+1}) \right) \end{aligned}$$

We can rewrite each incentive compatibility constraint that holds for period t in the form

$$\sup_{\{(c_i^x, z_i, I_i^y)\}_{i=t}^{\infty}} \sum_{i=t}^{\infty} \beta^i (u(c_i^x) + u(c_i^y)) \geq D^*(k_t, z_t) \quad (9)$$

where $D^*(k_t, z_t)$ is the solution to the sequential *Problem D*.

Problem D

$$D^*(k_t, z_t) = \sup_{(k_{t+1}, I_t^{y,d})} \left(u(f(k_t) - I_t^{x,d}) + u(pz_t - I_t^{y,d}) + \beta W(k_{t+1}) \right) \quad (10)$$

²¹Because the analyzed problem is nonstochastic the agents effectively decide about all allocations in the initial period $t = 0$ only. Nevertheless, they still face an infinity of incentive compatibility constraints that may constrain the feasible allocations at all other time periods in the future that need to be considered while optimization in the initial period.

is the value of defaulting on z amount of trade when the capital level is k . In the first period, the agent can consume or invest more of her home good X because she failed to ship the amount stipulated in their trade contract. After this default, the agent is banned forever from the international markets and lives in autarky, receiving the discounted utility of $\beta W(k_{t+1})$ in the future. Because the supremum is attained in the problem of maximizing utility after default (we maximize a continuous function over a compact set) we have a value function of defaulting $D(k_t, z_t) = \max_{(k_{t+1}, t_t^{y,d})} \left(u(k_t^x - t_t^{x,d}) + u(pz_t - t_t^{y,d}) + \beta W(k_{t+1}) \right)$. We gather the properties of the default function in Proposition 2.

Proposition 2 *$D(k, z)$ is strictly increasing, strictly concave and differentiable almost everywhere in (k, z) .*

This default option is different from the one assumed in Albuquerque and Hopenhayn (2004). Specifically, on some range we have $D(k, z) \geq \frac{k}{r}$ which is the upper bound on the outside option of the agents in the paper of these authors.

Let $U(k)$ be the value function corresponding to the value of the sequential Problem 2.

Proposition 3 *The value function $U(k)$ exists and is upper-semicontinuous in k .*

By strict monotonicity of D in z for a $z > 0$ we have $U(k) \geq D(k, z) > D(k, 0) = W(k)$. If at period t it is true that $z = 0$, $U(k) = D(k, 0) = W(k)$. Immediately we see that $U(k)$ need not be concave in k . Suppose that at k' in the neighborhood of k trade of some volume $z = \varepsilon > 0$ is possible and optimal, $U(k') \geq D(k', \varepsilon) > W(k')$ and $W(k)$ is a concave function. If $U(k)$ is concave but $U(k) < V(k)$ it need not be differentiable at the capital level k where the trade level first becomes unconstrained. We denote by k^{**} the steady state capital level in this system at which trade occurs.

3.4 A recursive formulation

Thanks to the result in Proposition 3 we can write the recursive formulation of the Problem 2 as

$$U(k) = \max_{(z, I^x, I^y)} u(c^x) + u(c^y) + \beta U(k') \quad (11)$$

subject to

$$\begin{aligned} k' &= (1 - \delta)k + I^x + I^y \\ I &= I^x + I^y \\ c^x &= f(k) - z - I^x \\ c^y &= pz - I^y \\ 0 &\leq c^y, 0 \leq c^x, 0 \leq z, 0 \leq I^x, 0 \leq I^y, \\ z &\in \Omega \cap [0, f(k)] \text{ where } \Omega = \{z : U(k) \geq D(k, z)\}. \end{aligned}$$

Let $a = (z, I^x, I^y)$ be a feasible action that satisfies the above constraints and let $A(U, k)$ be the feasible action set. Then we can rewrite the problem

$$U(k) = \max_{(z, I^x, I^y) \in A(U, k)} u(c^x) + u(c^y) + \beta U(k') \quad (12)$$

which will be useful in many of the proofs.

3.5 Characterization of the problem

Before investigating the properties of the value function $U(k)$ we need to define a few objects and make observations summarized in Lemmas 1–4. Let

$$U(k, z) = \max_{(I^x, I^y) \in A(U, k, z)} u(c^x) + u(c^y) + \beta U(k') \quad (13)$$

where the volume of trade z in the current period is given and $A(U, k, z)$ denotes the feasibility correspondence given z . Denote by $z^*(k)$ the first best volume of trade at k , by $\hat{z}^*(k)$ the optimal volume of trade at k under *Problem 2*. Furthermore, let $\bar{z}(k)$ be the largest volume of trade where $U(k, z) = D(k, z)$ and in case where $U(k, z) > D(k, z)$ for all feasible values of z take $\bar{z}(k) = f(k)$. It is true that $U(k, \hat{z}^*(k)) = U(k)$.

The following lemmas gather the properties of feasible trade volumes.

Lemma 1 *If $\bar{z}(k) \leq z^*(k)$ then $\hat{z}^*(k) = \bar{z}(k)$.*

This is intuitive; if the agent is constrained in her choices of z , she will choose to trade the maximum available amount. Thus, for further characterization of the problem, we can concentrate on studying the behavior of $\bar{z}(k)$ in the constrained region.

Lemma 2 *Suppose $\bar{z}(k) > 0$. Then $\bar{z}(k)$ is increasing in k , $\forall k' \geq k$. If under Problem D the agent would choose $c^{x,d} > 0$ then $\bar{z}(k)$ is strictly increasing in k , $\forall k' \geq k$.*

The incentives to trade increase with k if trade is feasible. This also means that as the capital stock increases, the constraint relaxes. The intuition for this is that the love-of-variety reason to trade is stronger for agents with higher income per capita. We thus obtain a positive relation between the level of trade and capital per capita in the region where trade occurs and the constraints are binding the agent. In the model investment in capital serves as a commitment device for the agent to gain credibility. This investment outlay is productive. Hence the positive reinforcement: as capital is accumulated, more trade is released to the agent, and the more the agent is allowed to trade, the more she is willing/able to invest.

What are the properties of optimal paths? The analyzed system is nonstochastic and we can observe that once the agent starts trading it cannot be in an optimal plan that at a later date trade is zero. Lemmas 1–2 enable us to show

Lemma 3 *Suppose in period t_0 , $\bar{z}(k_0) > 0$. Then $\hat{z}^*(k_t) > 0$, $\forall t > t_0$.*

In Lemma 4 we capture the case when trade is feasible at a later date on the optimal path.

Lemma 4 *Take an initial capital per capita k for which the solution to Problem 2 is a unique sequence of $\{\hat{z}^*(k_t)\}_{t_0}^\infty$. Then $\hat{z}^*(k_t) > 0 \Rightarrow \hat{z}^*(k_{t'}) > 0$, $\forall t' < t$.*

This means that if agents are credible enough in the future to be traded with, they will be able to use this credibility at an earlier date to conduct some trade. They can "cash in" their future willingness to trade. Therefore, the optimal consumption plan of the agent can either involve no trade at any period or positive trade at any date. On the optimal growth path, there is no threshold capital per capita level beyond which the country opens up to trade. Furthermore, if there exist two steady states of the system we can obtain a reversal of the behavior of trade/GDP that we have in the first-best world. We may observe an increasing sequence of trade if trade is constrained but positive. With only one steady state with trade, we might obtain this behavior only on some part of the domain (see Section 3.9 for examples).

Lemmas 1–4 give us a quick condition to check whether for a set of parameters trade always occurs in the optimal allocation. This is captured in Corollary 1 below.

Corollary 1 $\hat{z}^*(k^*) > 0 \Rightarrow \hat{z}^*(k) > 0, \forall k > 0$.

Whenever we want to check for the existence of no trade with the outside world in this economy, we need only to analyze the incentives the agents have at the autarkic steady state capital per capita level k^* . Agents that possess capital per capita endowments lower than k^* would never trade if the autarkic steady state exists. From the preceding discussion we also know, however, that if the autarkic steady state does not exist, then agents would trade for all positive capital per capita endowment levels.

The most complete characterization of the value function of *Problem 2* we can present is given in the following Proposition.

Proposition 4 $U(k)$ is strictly increasing and continuous in k . In the region where $U(k) = W(k)$ or $U(k) = V(k)$ the value function $U(k)$ is strictly concave and differentiable almost everywhere.

There is no discontinuity of $U(k)$ in k at *any* capital level.²² The agent need not be provided a large initial trade volume to be credible enough in international exchange and jump-start trade.

Figure 6 traces a theoretically possible value function of the general problem. $W(k)$ and $V(k)$ are continuous, differentiable almost everywhere and strictly concave. The value function of the constrained problem, $U(k)$, generally does not have these properties. Differentiability may fail at two points k_a and k_c apart from the capital per capita level at which the agents cease investment. At the level of capital k_a the agent in the economy is indifferent between remaining in autarky and decumulating capital to the steady state level of capital per capita k^* and starting to trade with the outside world and moving to k^{**} . At k_c we have $U(k_c, z^*) = V(k_c)$ and the agents can trade the optimal amount when $k \geq k_c$ but are constrained if $k < k_c$. However, if $k^{**} < k^{***}$ then we can have $W(k) \leq U(k) < V(k)$, $\forall k > 0$ so that k_c does not exist. Concavity of the value function $U(k)$ depends on how benefits to international trade are structured. If large benefits appear only for capital levels close to the free trade steady state, then the value function can be convex on the constrained region. All this depends on the behavior of the sequence of constraints. Figure 7 depicts the growth rates of an economy corresponding to the value functions shown in Figure 6. The patterns shown in Figures 6–7 are of course not the only ones that may occur. We can also have for example a case in which $W(k) < U(k) < V(k)$ and where a single steady state with trade exists.

We can partially characterize the optimal policy function.

Lemma 5 *An optimal policy function entails*

- a) $(I^x(k_t) > 0 \text{ and } I^y(k_t) = 0) \Leftrightarrow (u'(c^x(k_t)) > u'(c^y(k_t))),$
- b) $(I^x(k_t) > 0 \text{ and } I^y(k_t) > 0) \Leftrightarrow (u'(c^x(k_t)) = u'(c^y(k_t))),$
- c) $(I^x(k_t) = 0 \text{ and } I^y(k_t) > 0) \Leftrightarrow (u'(c^x(k_t)) < u'(c^y(k_t))).$

If agents are constrained so that little trade is feasible relative to the first-best world, they will consume the importable. As the level of trade that is available increases, the agent invests only from the imported good. If two steady states exist, then for capital values greater than k_a the agents invest out of the home good until trade is large enough so that the marginal utilities of consumption from both goods are equalized.

3.6 Steady state characterization

It is interesting to investigate how many steady states the analyzed system can have for a given p and β . A nontrivial steady state always exists in *Problem 2*. Proposition 5 answers in part the question when the autarkic steady state is a steady state of *Problem 2*.

Proposition 5 *If the autarky steady state exists in Problem 2 then*

$$u'(c^{x*}) > \beta p u'(0) \quad (14)$$

where c^{x*} is the autarky steady state consumption of the home good.

The intuition behind this result is that at the autarky steady state capital per capita value the added utility introduced by the consumption of the foreign good must be small.²³ This

²²The feasible trade volume for each k need not, however, be convex-valued.

²³This condition also means that there is no profitable stationary deviation from the autarkic steady state capital level in which the investment level remains constant but consumption of the importable is increased by $\varepsilon > 0$ in all future periods at the expense of the home consumption.

can be a result of a high discount factor (low β), which means that the reputational penalty is weak (the present discounted value of foregone utility is low). Adverse terms of trade (low p) hinder the attractiveness of foreign exchange. The price effect could be reinforced by traditional "iceberg" transaction costs or trade barriers. A home bias in consumption may be a cause of a low marginal utility of the foreign good relative to the steady state value of the home good. When we flip the sign of the inequality, we can also view this as a folk-theorem condition that is needed to be fulfilled for trade to be positive at the autarkic k^* level of capital per capita.

We can obtain only the necessary condition through the Lagrange multiplier method for the existence of the autarky steady state in the constrained problem. Sufficiency does not follow because the problem that we analyze is nonconcave. It will be clear by Lemma 7 that there exist values of β for which the autarky steady state is the unique steady state. Proposition 5 also gives a sufficient condition for a steady state with trade to exist. We cannot, however, provide sharper conditions on the existence of both types of steady states: the default option is too complicated to handle analytically. But we show the possibility that multiple steady states arise (an autarkic and a one in which trade occurs) through simulations reported in Section 3.9 below. Agents with different initial endowments of k can find themselves converging to different steady state levels. There might thus exist a pseudo-poverty trap: if the necessary conditions implied by inequality (14) hold, one can show through direct calculations that the capital level k^{***} corresponding to the first best *Problem 1a* could be achieved by the agent in autarky through capital accumulation and investment out of the home good, but it is not optimal for her to do so. The nonconvexities created by the incentive constraints may work in the model like a nonconvexity in technology analyzed in the poverty trap literature causing poverty traps to occur.

Suppose that there is a steady state with trade k^{**} and that trade is constrained at that steady state. Lemma 6 characterizes where the capital per capita associated with that steady state lies.

Lemma 6 *Suppose that $z(k^{**}) > 0$ at a steady state capital per capita level k^{**} . Then $k^* < k^{**} < k^{***}$.*

The incentive constraint on trade causes the importable used as an investment good to be harder to obtain comparing with the first-best case. To trade the same amount as in the first best the agent needs to have more capital at hand. This causes impediments to investment to arise. The steady state capital levels if the constraints are binding are therefore lower than the first-best steady state capital level. The interesting feature of the result lies in the fact that one of the steady states of the system – the one with capital per capita at k^{**} may depend on the existence of the trading constraints. At the steady state with positive trade it must be the case that the agent conducts investment out of the importable.

We arrive at a sufficiency condition for the autarky steady state to exist. Unfortunately we know that then it is the unique steady state of the economy. We cannot pin down the value of the discount factor for which the sufficiency result holds so that we could check whether the inequality (14) is satisfied.

Lemma 7 *$\exists \underline{\beta} > 0$ that a steady state with trade does not exist in Problem 2 but it does in Problem 1.*

This means that if the agent is impatient enough she would default on any trade volume. With a discount rate high enough there is no trade at all at any capital per capita level.

3.7 Extensions

So far we have developed the model assuming that there is no contract enforcement in international trade. In practice domestic courts might enforce international contracts if foreign

counterparties sue. Here we briefly extend the model to capture this. We model the level of domestic contract enforcement as an exogenous parameter q that denotes the probability of the contract being enforced (i.e. the payment exercised) before the consumption-savings decision if the agent attempts a default. After an unsuccessful default the agent is still punished and is confined to autarky forever on. The sequential formulation of *Problem D* in eq. (10) is modified to

$$D^*(k, z, q) = \sup_{(k_{t+1}, I_t^{y,d}, k_{t+1}(q), I_t^{y,d}(q))} \left[\begin{array}{l} (1-q) \left(\begin{array}{l} u(f(k) - I^{x,d}) \\ + u(pz - I^{y,d}) + \beta W(k_{t+1}) \end{array} \right) \\ + q \left(\begin{array}{l} u(f(k) - z - I^{x,d}(q)) \\ + u(pz - I^{y,d}(q)) + \beta W(k_{t+1}(q)) \end{array} \right) \end{array} \right] \quad (15)$$

where $k_{t+1}(q)$ and $I_t^{y,d}(q)$ are the choices made by the agent while attempting a default and being forced to repay on his imports.

It is trivial to show that the value function $D(k, z, q)$ of this modified problem exists. We have $D(k, z, q) < D(k, z, 0) = D(k, z), \forall q \in (0, 1]$. The value of the outside option for the agent falls as q increases not only because it is more risky to default but also because the expected gain is lower. Therefore $\bar{z}(k)$ increases as q does but for an agent for which $z^*(k) \leq \bar{z}(k)$ there is no effect on the chosen trade volume. The value of *Problem 2* with this modified function increases as q rises whenever $W(k) < U(k) < V(k)$. This change might be discontinuous with an infinitesimal change in q . One can show a modified version of inequality (14) that can hold so that there exist parameter values when there is no trade in autarky for a level of $q < 1$.

How do changes in future trade constraints stemming from different factors than those discussed above affect current trade constraints? Consider that in the following period the feasible trade volume \bar{z}' is exogenously given and that from then on the trading constraints are endogenously determined. If $\bar{z}'(k)$ is uniformly lower than $\bar{z}(k)$ then the value of the problem $U(k, z)$ falls if current trade volume $z \in (0, z^*(k))$ but $D(k, z)$ remains unchanged. Hence an anticipated increase in the constraints in the future for an economy decreases the current volume of constrained trade as well. On the other hand, a credible promise to ease the constraints in the future may cause a lock-in effect and start/increase exchange in earlier periods. This might work for example in the Turkey-EU relationship. Solely a credible promise of Turkey joining the EU may ease the hypothetical constraints faced by Turkish traders in international trade.

A fixed cost of international trade participation that would be borne in each period lowers the benefit from trade relatively to the default option $D(k, z)$ for all k and z values. Therefore a fixed cost in trade would exacerbate the analyzed contracting problem.

3.8 An excursion into general equilibrium

In this section we extend our basic model to show that our results hold in a general equilibrium formulation. Of course this is just one of the many ways one could attempt such an extension. Suppose there are 3 countries labeled h, i, j producing each a differentiated good $x_m, m = h, i, j$ using their home capital stocks k_m . The period utility function of each agent in country m is

$$u_m(\cdot) = u_m(c_m) + u_m \left(\sum_{n \neq m} c_n \right) \quad (16)$$

and the investment function is

$$I_m(\cdot) = I_m(x_m) + a \left(\sum_{n \neq m} I(x_n) \right) \quad (17)$$

where $a > 1$ denotes that the technology of investment out of the foreign goods yields more units of capital than that out of the home goods. From the perspective of a country, all foreign goods are perfect substitutes in consumption and investment.

The countries h and i have the same capital endowment k^{***} . One can think that they can have a high level of q , contract enforcement in trade between themselves, which permitted the achievement of such a high capital stock in the past. These two countries in the absence of the third trade and their growth path is that of a small open economy as in *Problem 1* in a first-best world. Investment is always conducted out of the foreign good. The equilibrium price is $p_h/p_i = 1$. The volume of trade at the open economy steady state is $2z = f(k^{***}) + \delta k^{***}$.

Let us now add the third country j with an endowment $k_j < k^{***}$. We have that $p_h/p_j = 1$ irrespective of k_j . By the balanced trade assumption the net demand for foreign goods coming from this country is zero. We can analyze the growth path of the economy of country j as if it were in isolation.²⁴ The difference with our initial assumptions in Section 2 is that although $p_h/p_j = 1$, the foreign goods are preferred over the home good as investment goods. The condition embodied in inequality (14) may hold. The volume of trade $z_{hj} + z_{jh} = z_{ij} + z_{ji} = z_j$. All results from Sections 3.1–3.7 carry through.

This shows that countries with high contract enforcement or high capital per capita (in the presence of multiple steady states) can trade with each other, while the ones with the contracting problem in international trade may not benefit from the conditions in the world markets and remain confined to autarky. This is consistent with the view that some researchers have that there might be a "twin peaks" distribution of countries in terms of income and that convergence clubs might exist (see for example Quah (1996)).

3.9 Simulations

3.9.1 Multiplicity of steady states

We present the results of value function iterations yielding multiple steady states of our Ramsey economy in Figure 8. The specification of the utility functions and the parameters in this exercise is $u(c) = \ln(c + 1)$, $\beta = 0.55$, $p = 1.3$, $\delta = 0.25$, $\alpha = 0.9$. The parameter $\beta = 0.55$ might seem to be low; one should note that the penalty that we impose to obtain analytical characterization – total market exclusion in case of default – is the harshest available to the principal. With milder penalties, the obtained effects would hold for higher values of β (see Section 3.9.3 below). The price assumed for the home good internationally $p = 1.3$ could be also set lower to obtain a similar effect. In this example, as the price approaches unity, there is only one autarkic steady state and there is no trade. The parameter $\alpha = 0.9$ is set to the value taken from the convergence literature that assumes k to be a broad measure of capital per capita.

In the example that we provide two steady states exist, with capital per capita k^* and k^{**} respectively. At k^* and on the convergence path to k^* there is no trade. After a threshold at k_a level, trade is positive and the system converges to k^{**} . The agents choose therefore the path of convergence depending on where their initial k lies. With the utility specification that we used the incentive to trade measured as a fraction of trade volume/GDP is larger in the first-best world the lower the capital per capita is. With the assumed parameter values we obtain an overturning of this monotonic relationship between trade/GDP and income per capita (see also the comparison to the iceberg trade costs in Section 3.9.4). It is clear that with a positive unanticipated shock to capital an economy that is for example in autarky can

²⁴With differently specified utility functions we can obtain price changes as the small open economy grows. As long as the Inada conditions on the consumption and investment demand of the developed countries do not hold and separability is assumed the prices that would be obtained internationally by country j products are bounded. We still have the possibility of multiple steady states (multiple prices can clear markets) if the price is too low. Then we could obtain country j that would remain in a poverty trap even though there would be world demand for its products at relative prices of country j products exceeding one.

become credible enough to start trading with the outside world and find itself on a different trajectory. On the other hand, a series of negative unanticipated shocks to capital can force a trading economy into autarky.

3.9.2 Comparative statics

We perform comparative statics on export volume/production ratios to observe the effects of parameter changes in our model on allocations. The openness measure is $1/2$ of the total trade volume/production due to the balanced trade assumption.

In Figures 9–12 odd-numbered panels depict simulations of export volume/GDP ratios vs. capital for the first-best problem. Even-numbered panels show the effects of the incentive problem for the same parameters as in the corresponding panel. We discuss comparative statics exercises for two base cases. The first is the example from Section 3.9.1 (depicted in Figures 9 and 10) where multiple steady states are present. The base parameters in this case that were used for comparison were $u(c) = \ln(c + 1)$, $\beta = 0.55$, $\delta = 0.25$, $p = 1.3$ and $\alpha = 0.9$. In Figures 11 and 12 we present results where in the base scenario trade is positive for all capital per capita values, but constraints are present at low income values. The underlying parameters used in this exercise were $u(c) = \ln(c + 1)$, $\beta = 0.6$, $\delta = 0.2$, $p = 1.3$ and $\alpha = 0.8$ unless otherwise indicated.

In all even-numbered panels we observe that the model with the friction can deliver many different patterns of openness as a function of capital, depending on the parameter values. This is in contrast with the first-best world where the trade volume to GDP ratio decreases monotonically with the increase of capital per capita. There initially the exports/GDP measure is one because of the agent's desire to quickly accumulate capital (the Inada condition on utility is broken). It is interesting to note that if the agents are constrained in the level of optimal trade then they are so for low levels of capital. As the constraints are eased, after some threshold the optimal first-best level of trade/GDP might be chosen. For the values of capital where constraints bind, growth of the economy is lower than in the first-best case.²⁵ Our model can therefore produce the same correlations that we observe in the data: countries with higher incomes are on average also the ones that are more open.²⁶

In panel 1 the first-best export volume/production ratio is presented. A more linear utility function of the agent leads to a higher share of international trade in consumption and investment demand: it is more profitable to substitute home for foreign goods. In panel 2 the effects of limited commitment are present. The more concave the agent's utility function is, the easier it is to sustain trade. The friction makes the largest impact on trade volume for utility functions where substitutability of the home and foreign goods is high and the demand is very sensitive to price changes.

An improvement in the terms of trade increase trade volume/GDP ratios (panels 3–4).

An increase in the depreciation rate of capital has little effect on the export volume/GDP ratio in the first-best world, although it may have strong implications in the world with limited commitment in trade. A high depreciation rate decreases the value of trading relative to autarky: at the steady state the investment in capital (that is preferably financed through imports) increases relative to low depreciation values.

In panels 7 and 8 the effects of the discount factors on export volume are shown: the harshness of the penalties for default is lower when individuals are very impatient and the corresponding export volumes are also lower. The simulations in the two panels of Figure 12 assumed $\delta = 0.35$.

²⁵We obtain qualitatively similar results when we use component utility functions of the exponential class $u(c) = -\theta \exp(-\theta c) + a$, where a is a constant.

²⁶If we introduce a more realistic setup, for example with bounded, additive i.i.d. shocks to capital at any capital per capita level that would occur between the shipment of the goods by the principal and their arrival, we can also have an easy explanation of the correlation between creditworthiness and capital per capita. Higher-income countries would be more credible, since their default would be less likely.

The effects of changes in capital intensity of the production function on openness are shown in panels 9 and 10. An increase in the capital intensity allows the constraint on trade to be weaker for lower values of capital. The value of international participation is higher with more capital intensive technology and lower rewards to labor, since the accumulation of the productive factor is cheaper by using importables. The deviation from the autarkic steady state to consume a small amount of the importable is more attractive, since the consumption of the agents at the steady state is larger as well. An increase in the parameter α leads the ratio $\frac{k^{***}}{k^*}$ to increase – the autarkic and the first-best world steady states of trade are further apart. A high α allows the multiplicity of steady states to exist; otherwise the steady states are "too close" and there is only one steady state with autarky or trade.

Panels 11 and 12 present changes in q , the enforcement parameter. In the first best world the change in this parameter does not change the volume of trade (we implicitly assumed that improvement of enforcement does not cost any resources). In the problem with the contracting friction, an increase in q raises the exports/GDP ratio if the agent is initially constrained but imports are positive. A small increase of q from zero does not lead always to the disappearance of the no trade region. In fact, there is a range of low levels of contract enforcement where the autarkic steady state is still present. The result that multiple steady states are present in our system holds on an open set of values of q in the neighborhood of zero. Hence, small increases in the enforcement of international contracts may not let an agent out of autarky.

3.9.3 Weaker punishments

We investigated allocations that arise when the punishment that is available to the principal involves only a one-period confinement to autarky. A weaker penalty of this sort in both aforementioned specifications produces only autarkic allocations. We obtain autarky as a result for discount factors as high as $\beta = 0.9$ and other parameter values set to $u(c) = \ln(c+1)$, $\delta = 0.25$, $p = 1.2$ and $\alpha = 0.8$. The curse of dimensionality and the need to recalculate the default option in its entirety after each value function iteration precludes us from giving a more detailed account of economies with trade and a one-period forgiving trigger punishment strategy. What we learn from our exercise, however, is that for any initially given set of parameters the introduction of this penalty scheme delivers lower incentives for the agents to perform and hence also lowers the achievable trade volume when trade is already constrained.

3.9.4 Trade costs

In Figure 13 we show how the imperfection in trade affects trade volumes differently from the Samuelsonian trade costs in the specification undertaken in Section 3.9.1. If trade costs are large ($\tau = 0.2$), the foreign good is not used for investment and the economy tends to the autarky steady state. Trade exists at that steady state but only for the love-of-variety reasons. With smaller trade costs ($\tau = 0.1$) the importable is used both for investment and consumption.²⁷ All this clearly depends on whether the price of the importable with trade costs imposed falls below $p = 1$ or not. In our problem with contracting frictions, the volume of trade is zero on the range of k where the economy remains in autarky. After the threshold k_a is reached trade volume increases sharply to later slowly converge towards the optimal free trade value.

The existence of Samuelsonian trade costs can emulate some patterns of trade achieved by our model, but only the export/GDP ratios monotonic in capital per capita. The friction we study allows for the existence of two steady states with the level of iceberg trade costs held constant as capital per capita is changed. Iceberg trade costs directly affect, however,

²⁷Trade costs in the range of $\tau \in [0.1, 0.2]$ are used inter alia in the simulation exercises of Obstfeld and Rogoff (2000).

the incentives of the agents to trade by lowering the gains from trade. This can be seen in inequality (14): the existence of (high) trade costs can push the economy into the no-trade region by also exacerbating the contracting friction.

3.10 Policy implications

We derive the policy implications that can solve at least partially the contracting problem that we discuss both from our theoretical results and from simulations.

In order to raise the attractiveness of international trade to the agent the central government should liberalize trade. We can see this when we associate trade barriers with imposed trade costs and use the intuition from inequality (14). With lower trade barriers, agents will observe higher benefits of international exchange and therefore become more credible to outside counterparties. We also note that the central government may slow down or stall the growth of the economy by placing high trade barriers. In a severe case, it may even cause a downturn and condemn the economy to eternal poverty (in the model). This can be possible if the stock of capital per capita falls below the level where the agent would decumulate capital even if there were no trade barriers. At this point we should also note the negative role of large trading blocks exerting market power in trade (for example in agriculture) that lowers the attractiveness of international exchange for agriculture exporters that in the view of our model may deny low-income countries market access and stall at the same time their growth. Trade agreements in which small, low-income economies liberalize trade more than large high-income countries may be beneficial for the former ones through the indirect positive effect of the incentives on the consumption surplus derived from trade and on their growth. Entering preferential trade agreements by a low-income country with one high-income country (for example the ex-colonizer) may be motivated aside from other considerations by the argument to jump-start growth by making the exchange with a high-income economy more attractive for traders from both countries and hence allowing investment imports to proceed. In a sense, a preferential trade agreement can be a device that lowers the commitment problems that individual agents may face.

A central planner that could improve domestic enforceability of international contracts and punish home defaulters would be able to increase the volume of trade if it were constrained. This should be stressed, for the ability to enforce international contracts domestically can eradicate the problem altogether. Improving the enforceability of contracts, however, may take time. Unification of exchange procedures and an improvement of international contracting helped to overcome some trade impediments. As examples we can name the Zollverein in XIXth century Germany or the European Union today. NAFTA and its Chapter 11 are a case of a trade agreement with a provision to protect foreign counterparties. Nevertheless, national sovereignty might prevent full enforceability from being achieved: fairness of the domestic authorities adjudicating claims in international disputes must in the end be self-enforcing. We also note that trade liberalization may not be enough to induce outside world traders to start trading with the domestic agents and that stronger contract enforcement would be required to allow for international exchange.

A benevolent central planner with the ability to tax in this limited commitment economy can improve allocations by easing agents' incentive compatibility constraints. Enhancing capital accumulation could give the incentives to acquire enough capital so as to start trading with the outside world. Any policy that raises the attractiveness of home products so that they command a higher world price or lowers trade costs also helps to provide incentives to agents to perform in contracts.

Agents from the outside world may also help in overcoming the obstacles in international exchange of low-income countries. There is a role for high income country export credit agencies. If the length of trade credit is extended, more trade might occur as the agents might be more credible to repay at a future date. We can also stress the usefulness of IMF

stand-by loans in times of external financial distress. If hard currency is difficult to obtain, counterparties from a country facing currency problems may default even involuntarily and break valuable ongoing trade relationships, therefore exacerbating the negative effects of a hypothetical crisis situation.²⁸ Multinational companies may overcome payment problems by inducing trade through subsidiaries. Foreign direct investment might be especially important for low-income countries that face constraints on international contracts (see Albuquerque (2003) for a model).

We should not forget that this discussion assumes that there are no other strategic considerations for the central planners of the countries in question. Note that small changes in policy can cause discontinuous effects on trade volume. Finally, policies that can ease the constraints on trade in the future (for example a credible trade liberalization announcement) and raise the utility obtained through trading today will also ease the constraints on trade that might be in place.

4 Correlations in the data

4.1 Testable implications

The model does not allow us to make predictions regarding trade openness (defined as volume of trade/production) unless we are able to account for all of the relevant parameters. If the friction in international trade that we analyzed works, we have shown in Section 3.9.2 that it can account for a vast array of correlations between capital and openness. The model predicts that the relationship between the current ratio of exports/capita and production per capita in period t should be:

$$\begin{aligned} \frac{z_t(k_t)}{f(k_t)} &= I_t^c \times \frac{\bar{z}_t}{f(k_t)}(p_t, k_t, \beta, \tau_t^p, \tau_t^t, q_t, b_t) \\ &\quad + (1 - I_t^c - I_t^d) \times \frac{z_t^*}{f(k_t)}(p_t, k_t, \beta, \tau_t^p, \tau_t^t, q_t) \end{aligned} \quad (18)$$

where I_t^c denotes the indicator variable of whether the country is constrained, I_t^d denotes the indicator variable of whether the country defaulted in the past, $\bar{z}_t(\cdot)$ and $z_t^*(\cdot)$ are functions of constrained and unconstrained trade volumes respectively, p_t are the terms of trade, k_t – capital per capita level (we could use income per capita), β – the discount factor, τ_t^p – trade costs stemming from policy (tariffs etc.), τ_t^t – other trade costs (distance, language, existence of container ports etc.), q_t – contract enforcement level between borders. The variable b_t denotes trade credit terms that limit the scope of trade. These could be thought of as specific limits (in case of centrally planned economies), exchange arrangements or trade credit contract terms.

There are obvious problems with verifying this equation empirically. We do not know what is "the true", unconstrained volume of trade on the growth path towards a steady state (if one exists). We also know that there are no countries that do not engage in exchange with the outside world and that generally the trade balances are nonzero. Many parameters (for example the discount rate or capital intensity) cannot be measured or may be estimated incorrectly. Our simulations indicate that even small changes in the underlying parameters may radically change the shape of the openness ratio. Other difficulties make the problem harder. The punishments for lack of payment of single agents do not shut off the trade of other traders from the same country. Even if we associate defaulting on trade with sovereign defaults, the observed punishments do not involve complete denial of trade with the defaulter. In estimating our model a problem arises that the volume of trade in any given period might

²⁸See Stephens (1998) on the role of export-credit agencies in the East Asian crisis and the policy conclusions he reaches.

depend on the whole future path of trade in the case of constrained economies. Hence we cannot test this equation directly and investigate whether the model is true or not. Therefore we can only provide evidence that supports the model by looking at the influence of contract enforcement on trade volume.

From our framework we can conclude that contract enforcement should be an important trade volume determinant if our story is true. Credit terms on trade flows should be also taken into account since these take into consideration expectations of future performance. We test these presumptions in a gravity model framework to verify the robustness of the correlations presented in Figures 3 and 4. Trade between two countries i and j relative to their two GDPs should be a function

$$\frac{z_t(k_t)}{f(k_{it})f(k_{jt})} = \chi(k_{it}, k_{jt}, \tau_{it}^p, \tau_{jt}^p, \tau_t^t, pop_{it}, pop_{jt}, q_{ijt}, b_{ijt}, p_{it}, p_{jt}) \quad (19)$$

where pop_{it}, pop_{jt} denote populations of the two countries. We need to control for the standard elements in a gravity equation. We are interested in the terms q_{ijt} and b_{ijt} that could include the quality of contract enforcement, credit terms, risk ratings, etc. In the data we could gather we do not have direct data on q_{ijt} or many choices for b_{ijt} . We use average maximum tenors (durations) that are granted on credit for long-term trade contracts in the practice of forfaiting.²⁹ We choose this variable because it accounts for a feature of true trade credit contracts offered by the market and it pertains to deals of private concern. It inherently involves a measure of future creditworthiness and an assessment of collection risk. Moreover, it may capture the interplay between institution effectiveness (especially that of the banking system) and contract enforcement.³⁰ Therefore, it is our prime choice over other institutional measures that might be available.

The estimating equation that we pursue is

$$\begin{aligned} \ln\left(\frac{X_{jit}}{Y_{it}Y_{jt}}\right) &= \beta_1 \ln(Ten_i) + \beta_2 \ln(Ten_j) + \beta_3 \ln(Y_{it}) + \beta_4 \ln(Y_{jt}) \\ &+ \beta_5 \ln(Y_{it}/Pop_{it}) + \beta_6 \ln(Y_{jt}/Pop_{jt}) + \beta_7 (\mathbf{D}_{ij}) + \beta_8 \mathbf{T} + \varepsilon_{ijt} \end{aligned} \quad (20)$$

where X_{ijt} denotes imports from countries j to i at time t , Y is real GDP, Pop is population, Ten are average maximum tenors, P is the terms of trade and \mathbf{D}_{ij} is the set of geographic and qualitative variables characterizing each dyad such as distance, common language, contiguity, trade agreements, tariffs, landlockedness or being an island, colonial past, area and the distance from the equator. The vector \mathbf{T} denotes time-specific dummies.

4.1.1 Data

We use data from the years 2001–2003 because of the availability of data on credit for trade – average maximum tenors on forfaiting contracts. The tenors for countries are taken from listings in Trade Finance, an industry journal. They indicate the maximum duration (up to 7 years) of the bills originating from trade contracts guaranteed by importer country banks that money-center banks are willing to discount. The averages from the quotations of 5 individual money center banks were taken out. The drawback of the data is that not all banks quote all countries at all times. This reflects their specialization or lack of quotes due to a zero rating. For example Vietnam is quoted only by 3 banks over the time period in the sample and Argentina and Zimbabwe, present in the listings for 2001, are missing in subsequent years. In the end we use data for countries that had their ratings between 0 and 7 years (maximum in the data set). This is because data on many countries, especially those

²⁹For a definition of forfaiting, see Section A.1.

³⁰Literally the data account for the willingness of money-center banks to discount bills originating from trade transactions that are guaranteed by the importer's domestic bank.

with poor credit, is missing and several countries are receiving maximum possible tenors. We do not know, however, what are the maximum tenors that the banks would be willing to provide for these countries above 7 years. In effect this excludes high-income and small countries from our data.

Data on bilateral trade come from the IMF DOTS database. Import and export volumes were deflated using US CPI and averaged to create total trade volumes between countries. Population, GDP, GDP per capita in PPP terms, CPI, GDP deflator, budget balance and CA series were obtained from the World Bank WDI database. From the CEPII we obtained data on geographical variables (distance between countries, contiguity, latitude, area, landlockedness, islands), languages and country allegiance. Data for FTAs and applied simple average MFN tariffs were obtained from the WTO website. Country credit ratings are taken from Institutional Investor. Whenever possible we supplemented the missing data with Economist Intelligence Unit figures. The resulting dataset consisted of 3725 dyads over 3 years (11175 observations). Countries included in the study are listed in the Appendix, Section A.4.³¹ Variable codes are given in Table 1.

4.1.2 Results

We summarize our results in Table 2.

In Column 1 we show the between regression estimates of the logarithm of the ratio of imports from country j to i and GDP per capita of countries i and j . The log of tenors of the importer country ($\ln Ten_i$) is significant at the 10% level. A 1% change in the minimum tenor in the dyad leads on average to an increase of the normalized trade volume by 0.15%. Surprisingly, the same measure for exporting country does not matter in the volume of trade ($\ln Ten_j$). In our regression we find that countries with higher income per capita trade more (variables $\ln Y_i/Pop_i$ and $\ln Y_j/Pop_j$). The size of the domestic market matters for trade: exporters (resp. importers) with larger GDP (variables $\ln Y_j$ and $\ln Y_i$) trade more (resp. less). A larger area of the importer country ($\ln Area_i$) has a negative effect on the volume of exchange.

In our sample trade volume in dyads with a larger number islands ($IslandNum_{ij}$) is higher. The remaining variables geographical variables show the expected signs. Two countries with a common colonizer ($ComCol_{ij}$), official and ethnic languages ($ComLangOff_{ij}$ and $ComLangEth_{ij}$ respectively) enjoy higher trade volumes. Contiguity ($Contig_{ij}$) and common FTA membership (FTA_{ij}) raises mutual trade. The logarithm of the level of average applied simple MFN tariffs ($\ln MFN_i MFN_j$) enters strongly into the regression. The logarithm of distance ($\ln Dist_{ij}$) and a larger number of landlocked countries ($LandlockNum_{ij}$) in the dyad tend to lower trade volumes. A larger logarithm of distances from the equator ($\ln Lat_i Lat_j$) and past allegiance to a common country ($SameCtry_{ij}$) also strengthens trade links. The dummies for being a colonized country in 1945 and the dummy indicating a colonial link between two countries do not enter significantly into the regression. The inclusion of a measure of terms of trade (the ratio of CPI prices to the GDP deflator) does not enter significantly into the regressions and restricts severely the set of available pairs for estimation. The coefficients on these three variables are not shown.

In the fixed effects regression with dummies included for each dyad (Column 3) the inclusion of the log of tenors of the importer is statistically significant at the 5% level. The point estimate of the effect of importer tenors is very close to that from the between regression (0.157). It is important that our measure comes statistically significant in this regression because the inclusion of dummies can capture a lot of specific information that is not controlled for in the between regression (for example the differences in the tariffs on specific classes of products).

³¹A detailed description of the data is available from the author.

4.1.3 Simultaneity and the robustness of results

Our data may suffer from simultaneity bias. The average maximum tenors that we use and overall country trade/GDP volume can be driven by some third variable. We therefore instrument for the tenors using one-period lagged budget balance, CPI, real interest rate, GDP growth and Institutional Investor credit ratings. We also use the constructed legal origins variables from the paper of Djankov et al. (2005). We note that we have excluded from the regressions most colonizing countries (except for Japan and Australia). We lose observations due to lack of some macroeconomic data and on legal origins in the end being restricted to 9252 observations.

In Column 2 we present the resulting IV regression. The instrumented variable estimate of the log of tenors is significant at the 1% level and its point estimate is more than two and a half times larger than the between one. We also achieve a higher, though not significant effect on the log of exporter tenors. Interestingly, these results are close to the ones that we find while bootstrapping the original between regression one thousand times taking draws of 2000 out of our 3725 groups included in the original estimation.

We also provide another set of estimates where instead of tenors we use credit ratings provided semi-annually by Institutional Investor (variables $\ln II_i$ and $\ln II_j$) that confirm our basic findings (Column 4). The Institutional Investor credit ratings do not directly pertain to trade contracts, however. They may still be interpreted as capturing indirectly the credibility of the banking system and the safety of the payment channel for international transactions.

4.2 Discussion

The estimation results support our model regarding the contract enforcement measure, however we do not want to overinterpret them. The variable that takes into consideration future performance of the economy and the probability of credit repayment – average maximum tenors – enters significantly into the regressions, pointing to the importance of credit standing for trade volume. Shorter maturities of bank-guaranteed transactions hurt trade. We do not know due to the lack of suitable data, however, what is the correlation of the willingness to finance long-term contracts with the willingness to offer short-term ones. We might conjecture that they could commove together. Stephens (1998) provides evidence that between 1997 and 1998 the short-term exposure of export credit agencies in Southeast Asian economies fell by 40% whereas the medium to long-run one only by 12%. We also note that the results that we obtain may be of relevance for growth because the medium to long-term trade that is financed by forfeiting often involves investment goods.

4.3 Other evidence and empirical strategies

Some existing studies provide indirect evidence that could be interpreted in the favor of the model. Anderson and Marcouiller (2002) find that survey measures of contract enforcement enter significantly into gravity equations and suggest a competing explanation for the stylized fact that high-income countries trade disproportionately with each other. The work of Rose (2004) finds that bilateral trade between countries is impaired after one of the countries reneges on its debt vis-à-vis the counterparty. The channel through which the default affects the country is not disentangled, however. Interestingly, while testing the robustness of his results Rose finds that the rating that a country receives in the Institutional Investor magazine capturing its perceived riskiness is also a significant variable in the gravity equations.

One could also perform case studies of countries that liberalize trade. According to the model, countries with higher incomes in PPP per capita terms, better contract enforcement and the ability to form long-run relationships would experience faster imports growth.³²

³²The difficulties and traps of similar studies are shown in Wacziarg and Welch (2003).

We could also look at countries that merge (for example East and West Germany) and divide (former Soviet Union, Yugoslavia, Czechoslovakia, Indonesia and East Timor) and analyze the trade patterns between them after the change.³³ The model would predict a larger fall in exchange between poorer former members of a union than richer ones.

5 Conclusions

Border-inflicted contractual impediments may severely hinder the volume of international exchange, especially for low-income economies. This in effect can depress the growth of small, open economies if investment goods are primarily obtained from abroad. In an extreme case, the inability to properly contract in international trade may lead an economy to a poverty trap and close the channel through which trade may affect growth – by raising investment rates. The achievable steady states per capita with trade can, however, also be dependent on the existence of the constraints. The ability to access foreign markets by small open economies may increase as capital is accumulated, as international exchange becomes more valuable and economies more interdependent. This model gives another answer to the question posed by Lucas (1990) why capital – here in the form of trade – does not flow to poorer countries. We also overcome the result of Marcet and Marimon (1992) showing how in the presence of limited commitment on international transactions international exchange exists on the transition path towards an open-economy steady state with trade.

Our model can provide an alternative account of the positive relationship between income and trade/GDP that exists in the data. We also support both theoretically and empirically the finding of Anderson and Marcouiller (2003) that contractual impediments on international transactions lower international trade. As a policy measure, therefore, we stress the importance of strengthening international contract enforcement and removing trade barriers so that a developing economy can benefit from international trade and achieve higher capital per capita in the long run. For empirical studies of international trade, our work calls for including in estimations, if available, measures of institutions connected with transaction processing and enforcement.

It would be interesting to extend this model of deterministic trade volume and input a full-blown trade model so that we could study how trade patterns may be affected by contractual problems in international transactions. We would like to study the following phenomena. Trade in differentiated goods often involves and requires long-term relationships whereas trade in homogenous products is more borne out to competition (see a study by Rauch (1999)). Differentiated products often have informational content incorporated in them and the buyer may not readily verify the quality of a good. Again this creates an ex-post moral hazard on the part of the seller as in our original model. To restore trade this would require a mechanism for providing incentives for the seller not to cheat on the quality of a product and reputation³⁴ could be used of the sort we included in the framework presented in this paper. We could use a dynamic version of the model of Davis (1995) to explore from the contract enforcement point of view whether low-income countries with poor institutions may face barriers in intra-industry trade which would cause them to specialize in a homogenous good, creating a potential poverty trap.

In further work it would be exciting to analyze the dynamics of the current account and break with the assumption of balanced trade to revisit puzzles analyzed by Obstfeld and

³³A study looking at trade flows after disintegrations was conducted by Fidrmuc and Fidrmuc (2000). These authors find that after disintegration of countries in 1990s trade volume falls relative to the earlier domestic level of exchange, but in 1998 the disintegrated countries still traded between each other from 2 to 30 times more than the volume of "normal" trade estimated from gravity equations for the rest of the world.

³⁴The quality assurance literature (see Klein and Leffler (1981) and Shapiro (1983)) analyzed similar issues. Klein and Leffler (1981) suggest the need for monopoly profits as a way of sustaining quality. A model of international trade with monopolists that improve on allocations in the presence of limited contract enforcement is studied by Michalski (2004).

Rogoff (2000). This would allow us to study the Feldstein-Horioka puzzle from the viewpoint of a contract enforcement model and possibly improve on earlier analyses in a growth economy as for example that presented in Marcet and Marimon (1992).

We believe that this framework can be also extended to study structural change and growth following Galor and Weil (2000), Hansen and Prescott (2002), Kongsamut et al. (2001) or Laitner (2000). We can study how a country evolves from an agrarian economy to an industrialized one and an economy that is integrated with the outside world. This would require a setup of a multisectoral trade model. An initial good productivity shock could provide a "takeoff" of growth of these economies in general equilibrium and a start of international trade.

Finally, it would be important to quantify how much trade volume is affected by the breakup of international transaction linkages and lower creditworthiness of payment intermediaries in and after financial crises and separate this from other macroeconomic effects that may drive international trade.

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A Appendix

A.1 Definition of forfaiting

There are many definitions of forfaiting. Let us present the ones that carry the most common elements.

”Forfaiting: A non-recourse export financing approach. The financier purchases bank avalized notes and carries all risks with no recourse to the exporter.” (www.nordea.com)

”Forfaiting without recourse to the exporter: Discount without recourse to the exporter of letters of credit or drafts accepted by Citibank or other banks (need to be asked for approval). A type of export financing in which the funds advanced to the exporter do not affect his credit line.” (www.latam.citibank.com)

Forfaiting allows the exporter to obtain a discounted flow immediately after the transaction is made at the same time offering a trade credit to the importer. Forfaiting contracts entail transactions from 90 days up to ten years. Usually the value of the underlying transaction is in excess of \$100,000 and may reach tens of U.S. million dollars worth. The transaction is usually without recourse, i.e. it does not depend on the underlying trade flow to occur or not. Traditionally the underlying transaction involved investment goods, but this changed in the 1990s to include any type of goods. Forfaiting is usually a free-market product offered by specialized investment banks (compiled after Ripley (1996) and Seyoum (2000)).

A.2 Examples of contract enforcement problems in international trade

An institutional setup consisting of banks, intermediaries and various contract types was created to mitigate payment problems in international trade. 35–50% of U.S. and UK trade is conducted via open account or consignment which constitutes pure trade credit (Seyoum (2000)). This is most often used through related counterparties. 90% of world trade is done on cash or short term credit (up to 180 days) basis (Stephens (1998)). The most popular payment instruments are letters of credit. None of the payment methods guarantees full security of the transaction either for the exporter or the importer. Often the problem of international contract enforcement is exacerbated by weak local institutions.

Letters of credit (L/Cs) and other payment documents need not be accepted by correspondent banks, constituting a breach of the contract. This can be due to many factors. About 50% of L/C documents contain discrepancies (see Seyoum (2000)). Trade Finance (2003a) (an industry journal) documents that Chinese banks were favoring their buyer clients in the first part of 2003 and unduly rejected at that time letters of credit, preventing delivery of steel products. The outstanding amount on these transactions at the time of reporting was in excess of \$100 million. The reasons cited for the rejection were falling steel prices: the buyers wanted to breach this way the already signed contracts with suppliers. Fafchamps (2004, p.59) notes: ”The absence of SGS-like³⁵ inspection for goods leaving Ghana, for instance, makes it easy for foreign clients to reject goods after delivery and extort discounts from Ghanaian exporters.”

International litigation may be costly, involving many courts and time consuming. Awards may be unenforceable. Trade Finance (2003b) provides an example. A Swiss trading firm was involved in a 7 year dispute with a state company from Uzbekistan. Despite being awarded by several international courts up to \$16 million they were unable to seize any assets belonging to Uzbekistan bar in France for ca. \$250,000. Other examples dealing with international litigation are provided in Nehring (2003) where the rulings of the Brazilian Supreme Court needed for confirmation of international arbitration awards against Brazilian firms are discussed.

³⁵SGS is a Swiss company that specializes in trade certification worldwide.

Payment documents also cost. Letters of credit for international transactions offered by Polish banks typically cost 0.15–0.2% of the contract with each change to the terms with the bank amounting to another 0.1–0.2% of the value. Such instruments in Africa cost triple the amount in the US and were reported by local exporters to be too costly to use (p. 73 of Biggs et al. (1996)). Fafchamps (2004) notes that African banks deliberately use the opportunity to notify the companies late about the fulfillment of payments to earn accruing interest on money in transit. Biggs et al. (1996) provide other examples of the deficiencies of the local banking sectors that hinder international payments.

Export credit agencies promote exports not only through cheap financing but also by insuring collection risks to exporters. A description of this is in Trade Finance (1999). An agreement on payment for US agricultural equipment was to be financed by Ukrainian exports proceeds deposited in escrow accounts at banks approved by Ex-Im. In the 5 years proceeding the agreement, \$400 million of financing was supported by the Ex-Im bank. Private financial institutions also play a role. An example is provided in Trade Finance (2001). Standard Bank London provided the necessary funds to build a fuel terminal to an importer that was granted by Zanzibar the sole right of fuel taxes collection. Without these provisions, the importer of fuel would not have the credibility to pay and no deal would take place.

A credit element is often present in cases of imports for investment that will reap returns over a prolonged time period. Examples of successful deals of this type abound. For example in the May 2005 issue of Trade Finance we find description of such deals between companies respectively from Germany and Armenia (machines for the foil industry), Finland and Russia (machines for the pulp industry), Japan and Oman (construction of a fertilizer factory) or U.S. and Brazil (helicopters for oil rigs).

A.3 Proofs

Proof of Proposition 1: Let $C(X)$ be the space of bounded continuous functions. Define the operator $T : C(X) \rightarrow C(X)$ as

$$(TV)(k) = \sup_{k' \in \Gamma_{ft}(k)} (u(f(k) - z - I^x) + u(pz - I^y)) + \beta V(k')$$

Consider first $V(k)$ and $V(\tilde{k})$ both being weakly monotone in k and \tilde{k} respectively and $k < \tilde{k}$. We want to show $(TV)(k) < (TV)(\tilde{k})$. Suppose that first we keep the same choice of the next period capital k' which is the optimal choice under initial capital k . This is feasible, since $\Gamma_{ft}(k) \subset \Gamma_{ft}(\tilde{k})$ and with the higher capital level the agents can replicate the optimal decisions undertaken at k' . We have

$$\begin{aligned} (TV)(k) &= \sup_{k' \in \Gamma_{ft}(k)} (u(f(k) - z(k') - I^x(k')) + u(pz(k') - I^y(k'))) + \beta V(k') \\ &< \left(u\left(f\left(\tilde{k}\right) - z(k') - I^x(k')\right) + u(pz(k') - I^y(k')) \right) + \beta V(k') \\ &\leq \sup_{k'' \in \Gamma_{ft}(\tilde{k})} \left(u\left(f\left(\tilde{k}\right) - z(k'') - I^x(k'')\right) + u(pz(k'') - I^y(k'')) \right) + \beta V(k'') \\ &= (TV)(\tilde{k}) \end{aligned}$$

To show strict concavity of $V(k)$ observe that we have $\forall \theta \in (0, 1), k \neq \tilde{k}$

$$\begin{aligned}
& \left[\begin{aligned} & \theta (u(f(k) - z(k') - I^x(k')) + u(pz(k') - I^y(k'))) \\ & + (1 - \theta) \left(u \left(f(\tilde{k}) - z(\tilde{k}') - I^x(\tilde{k}') \right) + u \left(pz(\tilde{k}') - I^y(\tilde{k}') \right) \right) \end{aligned} \right] \\
< & \left[\begin{aligned} & \theta (u(f(k) - z(k') - I^x(k'))) + u \left(f(\tilde{k}) - z(\tilde{k}') - I^x(\tilde{k}') \right) \\ & + u \left(\theta (pz(k') - I^y(k')) + (1 - \theta) (pz(\tilde{k}') - I^y(\tilde{k}')) \right) \end{aligned} \right] \\
< & \left[\begin{aligned} & u \left(\theta (f(k) - z(k') - I^x(k')) + (1 - \theta) \left(f(\tilde{k}) - z(\tilde{k}') - I^x(\tilde{k}') \right) \right) \\ & + u \left(\theta (pz(k') - I^y(k')) + (1 - \theta) (pz(\tilde{k}') - I^y(\tilde{k}')) \right) \end{aligned} \right] \\
< & \left[\begin{aligned} & u \left(f \left(\theta k + (1 - \theta) \tilde{k} \right) - \theta z(k') - \theta I^x(k') - (1 - \theta) z(\tilde{k}') - (1 - \theta) I^x(\tilde{k}') \right) \\ & + u \left(\theta (pz(k') - I^y(k')) + (1 - \theta) (pz(\tilde{k}') - I^y(\tilde{k}')) \right) \end{aligned} \right]
\end{aligned}$$

because of the strict concavity of utility and production functions.

Suppose $k' \in \Gamma_{ft}(k)$ and $\tilde{k}' \in \Gamma_{ft}(\tilde{k})$. Then $\theta k' + (1 - \theta) \tilde{k}' \in \Gamma_{ft}(\theta k + (1 - \theta) \tilde{k})$ for all $\theta \in (0, 1)$ because the action space is convex. Take a concave function V and show that the operator T preserves concavity; moreover, under our assumptions, it induces strict concavity. $\forall \theta \in (0, 1)$ we have $\theta \beta V(k') + (1 - \theta) \beta V(\tilde{k}') \leq \beta V(\theta k + (1 - \theta) \tilde{k}')$. Now,

$$\begin{aligned}
& \theta (TV)(k) + (1 - \theta) (TV)(\tilde{k}) \\
= & \left[\begin{aligned} & \theta (u(f(k) - z(k') - I^x(k')) + u(pz(k') - I^y(k'))) \\ & + (1 - \theta) \left(u \left(f(\tilde{k}) - z(\tilde{k}') - I^x(\tilde{k}') \right) + u \left(pz(\tilde{k}') - I^y(\tilde{k}') \right) \right) \\ & + \theta \beta V(k') + (1 - \theta) \beta V(\tilde{k}') \end{aligned} \right] \\
\leq & \left[\begin{aligned} & \theta (u(f(k) - z(k') - I^x(k')) + u(pz(k') - I^y(k'))) \\ & + (1 - \theta) \left(u \left(f(\tilde{k}) - z(\tilde{k}') - I^x(\tilde{k}') \right) + u \left(pz(\tilde{k}') - I^y(\tilde{k}') \right) \right) \\ & + \beta V(\theta k + (1 - \theta) \tilde{k}') \end{aligned} \right] \\
< & \left[\begin{aligned} & u \left(f \left(\theta k + (1 - \theta) \tilde{k} \right) - \theta z(k') - \theta I^x(k') - (1 - \theta) z(\tilde{k}') - (1 - \theta) I^x(\tilde{k}') \right) \\ & + u \left(\theta (pz(k') - I^y(k')) + (1 - \theta) (pz(\tilde{k}') - I^y(\tilde{k}')) \right) \end{aligned} \right] \\
\leq & \sup_{k'' \in \Gamma_{ft}(\theta k + (1 - \theta) \tilde{k})} \left\{ u(\gamma k + (1 - \gamma) \tilde{k}, k'') + \beta V(k'') \right\} \\
= & (TV)(\theta k + (1 - \theta) \tilde{k})
\end{aligned}$$

By the Benveniste and Scheinkman result, $V(k)$ is differentiable almost everywhere in the interior because $V(k)$ is strictly concave and $u(\cdot)$ is differentiable in k . ■

Proof of Proposition 2: $D(k, z)$ is strictly increasing in z because $u(pz_t - I_t^y)$ is. Because all elements of the maximized function are strictly concave in (k, z) (following from the assumptions on the investment function $g(I^x, I^y)$), from the Maximum Theorem under convexity it follows that $D(k, z)$ is strictly concave in (k, z) . Because the constraint set has a convex graph, there is a unique set of maximizers for each (k, z) . From the Benveniste and Scheinkman result we conclude that $D(k, z)$ is differentiable in (k, z) and specifically that $D_z(k, z) = pu'(pz - I_t^{y,d}) > 0$. This D_z is continuous and differentiable and $D_{zz} < 0$. We also have $D_k(k, z) \leq u'(c^x - I_t^{x,d})(f'(k) + (1 - \delta))$. ■

Proof of Proposition 3: A direct application of Lemma 2.12 in Rustichini (1998a). ■

Proof of Lemma 1: The case when $\bar{z}(k) = 0$ is obvious. When $\bar{z}(k) > 0$ and $z^*(k) > \bar{z}(k)$ suppose that $\tilde{z}(k) < \bar{z}(k)$ is optimal. Since in the constrained region $u'(c^x) < pu'(c^y)$ we can increase the current period utility of the agent by increasing trade to $\bar{z}(k)$, leaving

next period choice of k' intact and boosting the consumption of c^y , the importable. Since $p > 1$ this dominates the previous choice. ■

Proof of Lemma 2: We argue by contradiction. Suppose $\bar{z}(k) > 0$ and take $k' > k$. Suppose that $U(k, \bar{z}) = D(k, \bar{z})$ but $U(k', \bar{z}) < D(k', \bar{z})$.

By strict concavity of D we have $D(k', \bar{z}) < D(k, \bar{z}) + (k' - k) D_k(k, \bar{z})$ which is equal to $D(k, \bar{z}) + (k' - k) u'(c^{x,d}) (f'(k) + (1 - \delta))$ where $c^{x,d}$ is the consumption level of the home good maximizing $D(k, \bar{z})$.

Define $\tilde{U}(k', \bar{z}) = U(k, \bar{z}) + u(c^{x,d} - \bar{z} + f(k') - f(k) + (1 - \delta)(k' - k)) - u(c^{x,d} - \bar{z})$. We have $U(k, \bar{z}) < \tilde{U}(k', \bar{z}) \leq U(k', \bar{z})$.

First we tackle the case where it would be optimal for the agent to consume zero of the home goods after default. Then $D(k', \bar{z}) < D(k, \bar{z}) + (k' - k) u'(0) (f'(k) + (1 - \delta))$ while $\tilde{U}(k', \bar{z}) = U(k, \bar{z}) + u(f(k') - f(k) + (1 - \delta)(k' - k)) - u(0)$ which for small change in k are equal. If after default there would be consumption of the home good, choose z so that $c^{x,d} - z > 0$. By concavity

$$\begin{aligned} & u(c^x - z + f(k') - f(k) + (1 - \delta)(k' - k)) - u(c^x - z) \\ & \geq u'(c^x - z + f(k') - f(k) + (1 - \delta)(k' - k)) [f(k') - f(k) + (1 - \delta)(k' - k)] \end{aligned}$$

Take $\varepsilon = k' - k > 0$. By concavity of f we have $f(k') - f(k) \geq f'(k + \varepsilon)\varepsilon$. For ε small enough we have $c^x - z + f'(k + \varepsilon)\varepsilon + (1 - \delta)\varepsilon < c^x$ because $z > 0$. By continuity of u' and f'

$$u'(c^x - z + f'(k + \varepsilon)\varepsilon + (1 - \delta)\varepsilon) (f'(k + \varepsilon) + (1 - \delta)) - u'(c^x) (f'(k) + (1 - \delta)) > 0$$

Collecting the terms we notice in the interior that

$$D(k', \bar{z}) < \tilde{U}(k', \bar{z}) \leq U(k', \bar{z})$$

By the definition of \bar{z} , it must be the case that $\bar{z}(k') \geq \bar{z}(k) > 0$. If the case with no consumption is outruled, $\bar{z}(k') > \bar{z}(k)$. ■

Proof of Lemma 3: Suppose that on the optimal path no trade is prescribed in the following period and the optimal capital choice is k' . Then $U(k') = D(k', 0) = W(k')$. If $z(k) > 0$, then the agent can increase her welfare by defaulting today and obtaining the autarky utility for ever on. Consequently, it must be the case that $D(k, z) > U(k) \forall z(k) > 0$ at that k . ■

Proof Lemma 4: Consider the programming problem in Section 3.4. Assume that the current period is the last period in which $\bar{z}(k) = 0$ and that from the next period $\bar{z}(k') > 0$. Then, it must be the case in the current period that $U(k) = D(k, \bar{z}(k)) = D(k, 0) = W(k)$ and $U(k') \geq D(k', z) > D(k', 0) = W(k')$. But, with $U(k) = W(k)$ there exists one path with no trade, so we contradict uniqueness. ■

Proof of Proposition 4: For the strict monotonicity result, take $k < k'$. Since $A(k) \subset A(k')$ it is possible to select at k' continuation values that are optimal at k and consume the remaining resources, increasing instantaneous utility. Hence $U(k') > U(k)$. For continuity, we need to ascertain that the correspondence $A(U, k)$ is a compact-valued and continuous correspondence. The argument follows from Lemma 2.12 of Rustichini (1998a). Compact-valuedness comes from the fact that the incentive compatible choices of z are in a closed set defined for each k by $\{z : U(k, z) \geq D(k, z)\}$ contained in a compact-valued set of feasible trade volumes in the first best problem. Furthermore, the constraints $D(k, z)$ are continuous in k and therefore $A(U, k)$ is upper-hemicontinuous. The set of feasible sequences is bound by two continuous functions - an aggregator and the default function $D(k, z)$, hence $A(U, k)$ is also lower-hemicontinuous. We have that the current period utility functions are continuous in k and the feasibility correspondence is nonempty, compact valued and continuous. The result follows from the Maximum Theorem. Furthermore, the set of maximizers $k^{*f}(k)$ is an

upper-hemicontinuous correspondence. The latter part is immediate from the properties of $W(k)$ and $V(k)$. ■

Proof of Lemma 5: To show a) suppose that $I^y(k_t) > 0$ but $(u'(c^x(k_t)) > u'(c^y(k_t)))$. Consider a deviation where the consumption of the home good is lowered by ε and the consumption of the importable increased by ε , leaving total investment constant. We obtain an increase in the utility of the agent. Points b) and c) can be proved using similar reasoning. ■

Proof of Proposition 5: We characterize the problem through Lagrange multipliers. Assume that Lagrange multipliers exist.

The Lagrangian of the problem is

$$\begin{aligned} & \sum_{t=0}^{\infty} \beta^t \left[\begin{aligned} & (u(c_t^x) + u(c_t^y)) \\ & + \phi_t((1-\delta)k_t + I_t^x + I_t^y - k_{t+1}) \\ & + \kappa_t(f(k_t) - z_t - I_t^x - c_t^x) \\ & + \varphi_t(pz_t - I_t^y - c_t^y) \\ & + \zeta_t c_t^x + \zeta'_t c_t^y + \theta_t z_t + \nu_t I_t^x + \eta_t I_t^y \end{aligned} \right] \\ & + \sum_{i=0}^{\infty} \lambda_i \left(\sum_{t=i}^{\infty} \beta^{t-i} ((u(c_t^x) + u(c_t^y)) - D(k_i, z_i)) \right) \end{aligned} \quad (21)$$

The FOCs of the problem with respect to $c_t^x, c_t^y, k_t, z_t, I_t^x, I_t^y$ in period $t \geq 1$ are respectively

$$\beta^t (u'(c_t^x) - \kappa_t + \zeta_t) = - \sum_{i=0}^t \lambda_i \beta^{t-i} u'(c_t^x) \quad (22)$$

$$\beta^t (u'(c_t^y) - \varphi_t + \zeta'_t) = - \sum_{i=0}^t \lambda_i \beta^{t-i} u'(c_t^y) \quad (23)$$

$$\beta^t (\phi_t(1-\delta) - \beta^{-1}\phi_{t-1} + \kappa_t f'(k_t)) = \lambda_t D_k(k_t, z_t) \quad (24)$$

$$\beta^t (-\kappa_t + \varphi_t p + \theta_t) = \lambda_t D_z(k_t, z_t) \quad (25)$$

$$\beta^t (\phi_t - \kappa_t + \nu_t) = 0 \quad (26)$$

$$\beta^t (\phi_t - \varphi_t + \eta_t) = 0 \quad (27)$$

plus the additional equations from FOC with respect to the multipliers

$$(1-\delta)k_t + I_t^x + I_t^y - k_{t+1} = 0 \quad (28)$$

$$f(k_t) - z_t - I_t^x - c_t^x = 0 \quad (29)$$

$$pz_t - I_t^y - c_t^y = 0 \quad (30)$$

We impose multiplier values on the first order conditions that are obtained in the autarky steady state and verify that the sequence of Lagrange multipliers $\{\lambda_t\}_{t=0}^{\infty}$ are summable and belong to the space ℓ^1 . Specifically, at the autarky steady state we know that $z = 0, I_t^y = 0, c_t^y = 0, D(k, 0) = W(k)$. The constraints $0 \leq c_t^x, 0 \leq c_t^y, 0 \leq z_t, 0 \leq I_t^x$ are nonbinding and the corresponding Lagrange multipliers are zero. After imposing these conditions we can rewrite the first order conditions as

$$\beta^t \kappa_t = u'(c^{x*}) \left(\beta^t + \sum_{i=0}^t \lambda_i \beta^{t-i} \right) \quad (31)$$

$$\beta^t \varphi_t = u'(0) \left(\beta^t + \sum_{i=0}^t \lambda_i \beta^{t-i} \right) \quad (32)$$

$$\beta^t (\phi_t(1-\delta) - \beta^{-1}\phi_{t-1} + \kappa_t f'(k^*)) = \lambda_t D_k(k^*, 0) \quad (33)$$

$$\beta^t (-\kappa_t + \varphi_t p) = \lambda_t D_z (k^*, 0) \quad (34)$$

$$\phi_t = \kappa_t \quad (35)$$

$$\phi_t = \varphi_t - \eta_t \quad (36)$$

Using (34) and (32), substituting for $a = \frac{(pu'(0) - u'(c^{x*}))}{pu'(0)}$ we can express (31) as

$$a = \frac{\lambda_t}{\left(\beta^t + \sum_{i=0}^t \lambda_i \beta^{t-i}\right)} \quad (37)$$

Now we can calculate

$$\frac{\lambda_t}{\lambda_{t-1}} = \frac{\beta}{(1-a)} \quad (38)$$

It must be true that $\frac{\lambda_t}{\lambda_{t-1}} < 1$ for the sequence $\{\lambda_t\}_{t=0}^\infty$ to be summable. This implies $u'(c^{x*}) > \beta pu'(0)$ noting that $D_z(k, 0) = pu'(0)$. We can also note that there can be no other steady state with $I^y = 0$ than at that with k^* (which at this point does not mean that no trade at k^* steady state is possible – see Lemma 7). This can be seen by using eq. (33) and substituting from eq. (34). The only way that $\frac{\lambda_t}{\lambda_{t-1}}$ is equal to the expression obtained from eq. (38) is when $\beta(f'(k) + (1-\delta)) = 0$ or when $k = k^*$. ■

Proof of Lemma 6: We start by showing that $k^* < k^{**} < k^{***}$ when investment is conducted at the steady state from the importable. It is easy to construct a profitable deviation under the assumption that $k^{***} < k^{**}$ but one cannot verify that it is feasible, therefore contradicting the assumption. We need to revert to the analysis of the first order conditions of the problem.

From equations (22)–(24) and (26)–(27) we obtain

$$\frac{u'(c^x) f'(k) - u'(c^y) (\beta^{-1} - (1-\delta))}{(D_k(k, z) - \beta^{-1} u'(c^y))} = \frac{\lambda_t}{\left(\beta^t + \sum_{i=0}^t \lambda_i \beta^{t-i}\right)}$$

If $(D_k(k, z) - \beta^{-1} u'(c^y)) > 0$ then $f'(k) > f'(k^{***})$. We also can get

$$\beta^{-1} \left(1 - \frac{u'(c^x) f'(k) - u'(c^y) (\beta^{-1} - (1-\delta))}{(D_k(k, z) - \beta^{-1} u'(c^y))} \right) = \frac{\lambda_{t-1}}{\lambda_t}$$

and from $\frac{\lambda_{t-1}}{\lambda_t} > 1$, and assuming $(D_k(k, z) - \beta^{-1} u'(c^y)) < 0$ this yields

$$\frac{(1-\beta) D_k(k, z) + \delta u'(c^y)}{u'(c^x)} < f'(k)$$

Comparing with

$$f'(k) = \frac{D_k(k, z) (pu'(c^y) - u'(c^x))}{D_z(k, z) u'(c^x)} - \beta^{-1} \frac{u'(c^y) (pu'(c^y) - u'(c^x))}{D_z(k, z) u'(c^x)} + \frac{u'(c^y)}{u'(c^x)} (\beta^{-1} - (1-\delta))$$

and noting that it must be true that $\frac{(pu'(c^y) - u'(c^x))}{D_z(k, z)} < (1-\beta)$ for the multipliers to be summable we obtain

$$(1-\beta) D_k(k, z) < (1-\beta) D_k(k, z) \quad (39)$$

a contradiction. We also notice that

$$\begin{aligned} f'(k) &< (1-\beta) \left(\frac{D_k(k, z)}{u'(c^x)} - \beta^{-1} \frac{u'(c^y)}{u'(c^x)} \right) + \frac{u'(c^y)}{u'(c^x)} (\beta^{-1} - (1-\delta)) \\ &< (1-\beta) \frac{D_k(k, z)}{u'(c^x)} + \frac{u'(c^y)}{u'(c^x)} \delta \end{aligned} \quad (40)$$

Because $\frac{u'(c^y)}{u'(c^x)} \leq 1$,

$$f'(k) < \beta^{-1} - 1 + \delta = f'(k^*)$$

so that $k^{**} > k^*$.

For the case with the home good used for investment at the steady state, we obtain

$$\frac{u'(c^x) (f'(k) + (1 - \delta) - \beta^{-1})}{(D_k(k, z) - \beta^{-1} u'(c^x))} = \frac{\lambda_t}{\left(\beta^t + \sum_{i=0}^t \lambda_i \beta^{t-i} \right)}$$

If $(D_k(k, z) - \beta^{-1} u'(c^x)) > 0$ then $f'(k) > f'(k^*)$. O/w we obtain a contradiction as above in (39). However, we can obtain a condition similar to inequality (40) and see that it always must be true that $f'(k) < f'(k^*)$. Hence, there can be no steady state with trade and the home good being used for investment reasons. ■

Proof of Lemma 7: Start from a steady state with trade and consider the default option. We need to show that $D(k^{**}, z(k^{**})) > V(k^{**})$ for some $\hat{\beta}$ where double asterisks denote steady state values where trade is present and $I^y > 0$.

Notice that

$$\begin{aligned} D(k^{**}, z(k^{**})) &= \sup_{(k_{t+1}, I_0^y)} (u(f(k^{**}) - I_t^x) + u(pz(k^{**}) - I_t^y) + \beta W(k_{t+1})) \\ &\geq (u(f(k^{**}) - I_t^{x,**}) + u(pz(k^{**}) - I_t^{y,**}) + \beta W(k^{**})) \\ &= \hat{D}(k^{**}, z(k^{**})) \end{aligned}$$

where $I_t^{x,**}$ and $I_t^{y,**}$ is the optimal investment at the analyzed steady state. We have that $W(k^{**}) > u(f(k^{**}))$ and substitute for the steady state value of $V(k^{**})$.

$$\begin{aligned} &\hat{D}(k^{**}, z(k^{**})) - V(k^{**}) \\ &= u(f(k^{**}) - I_t^{x,**}) - u(f(k^{**}) - z^{**} - I_t^{x,**}) + \beta(W(k^{**}) - V(k^{**})) \\ &= u(f(k^{**}) - I_t^{x,**}) + \beta W(f(k^{**})) \\ &\quad - \frac{1}{1 - \beta} u(f(k^{**}) - z^{**} - I_t^{x,**}) - \frac{\beta}{1 - \beta} u(pz^{**} - I_t^{y,**}) \end{aligned} \tag{41}$$

We will show that for a β small enough the above expression is higher than zero, preventing any steady state with trade to exist.

We show that $\beta W(k^{**}) - \frac{\beta}{1 - \beta} u(f(k^{**}) - z^{**} - I_t^{x,**}) > 0$ for small β . Suppose that the inequality holds. By concavity of the utility function and using the fact that $u(0) = 0$ we have

$$u\left(\frac{1}{(1 - \beta)} (f(k^{**}) - z^{**} - I_t^{x,**})\right) > \frac{1}{1 - \beta} u(f(k^{**}) - z^{**} - I_t^{x,**}) \tag{42}$$

Now if β is small we show that

$$\begin{aligned} u(f(k^{**})) &> u\left(\frac{1}{1 - \beta} (f(k^{**}) - z^{**} - I_t^{x,**})\right) \\ (1 - \beta) f(k^{**}) &> f(k^{**}) - z^{**} - I_t^{x,**} \end{aligned}$$

to obtain

$$z^{**} + I_t^{x,**} > \beta f(k^{**}) \tag{43}$$

At the steady state with trade and investment in $I^y > 0$ we know that from the FOC characterization in eqs. (22)-(30) it must be the case then that $u'(pz^{**} - I^{y**}) < u'(f(k^{**}) - z^{**})$ so

that $z^* \geq \frac{1}{p+1}f(k)$. It suffices that $\beta \leq \frac{1}{p+1}$ for $\beta W(k^{**}) - \frac{\beta}{1-\beta}u(f(k^{**}) - z^{**} - I_t^{x,**}) > 0$. We now investigate when the remainder

$$u(f(k^{**}) - I_t^{x,**}) - u(f(k^*) - z^{**} - I_t^{x,**}) - \frac{\hat{\beta}}{1-\hat{\beta}}u(pz^{**} - I_t^{y,**}) > 0 \quad (44)$$

Using concavity properties of the utility function we can rewrite eq. (44):

$$z^{**}u'(f(k^{**}) - I_t^{x,**}) > \frac{\hat{\beta}}{1-\hat{\beta}}u(pz^{**} - I_t^{y,**}) \quad (45)$$

Using concavity and the fact that $u(0) = 0$

$$\frac{\hat{\beta}}{1-\hat{\beta}}(pz^{**} - I_t^{y,**})u'(0) > \frac{\hat{\beta}}{1-\hat{\beta}}u(pz^{**} - I_t^{y,**}) \quad (46)$$

Combining (45) and (46) we have that

$$\frac{z^{**}u'(f(k^*) - I_t^{x,**})}{((pz^{**} - \delta k^{**})u'(0) + z^{**}u'(f(k^{**}) - I_t^{x,**}))} > \hat{\beta} \quad (47)$$

We observe that by working with the denominator we can find a limiting value for the expression (47) as

$$\begin{aligned} \frac{z^{**}u'(f(k^*) - I_t^{x,**})}{((pz^{**} - \delta k^{**})u'(0) + z^{**}u'(f(k^{**}) - I_t^{x,**}))} &> \frac{z^*u'(f(k^*) - I_t^{x,*})}{((p+1)z^* - \delta k^*)u'(0)} \\ &> \frac{u'(f(k^*) - I_t^{x,*})}{((p+1)u'(0))} \\ &> \hat{\beta} \end{aligned} \quad (48)$$

Therefore, for sufficiently small values of $\hat{\beta}$ the expression (41) is positive, as desired. Now we need to inspect the possibility of a steady state with trade and $I^x > 0$. Imposing steady state conditions with trade on eqs. (22)–(30) and solving for the sequence of multipliers $\{\lambda_t\}_{t=0}^\infty$ we come to a contradiction unless $\beta(f'(k) + (1-\delta)) = 1$ (see Lemma 6) so that the only steady state then would be at the autarkic steady state. But we note by Lemma 6 that at k^* there cannot be a steady state with positive trade. ■

A.4 Countries included in the estimation

Algeria, Australia, Bahrain, Bangladesh, Bolivia, Brazil, Bulgaria, Chile, China, Colombia, Costa Rica, Croatia, Cyprus, Czech Republic, Dominican Republic, Ecuador, Egypt, El Salvador, Estonia, Ghana, Greece, Guatemala, Hong Kong, Hungary, Iceland, India, Indonesia, Iran, Israel, Japan, Jordan, Kazakhstan, Kenya, Korea Rep., Kuwait, Latvia, Lebanon, Libya, Lithuania, Macedonia FYR, Malaysia, Malta, Mauritius, Mexico, Morocco, Mozambique, Nigeria, Oman, Panama, Paraguay, Peru, Philippines, Poland, Qatar, Romania, Russian Federation, Saudi Arabia, Slovak Republic, Slovenia, South Africa, Sri Lanka, Syrian Arab Republic, Tanzania, Thailand, Trinidad and Tobago, Tunisia, Turkey, Uganda, United Arab Emirates, Uruguay, Venezuela, Vietnam, Zambia.

A.5 Figures and Empirical results tables

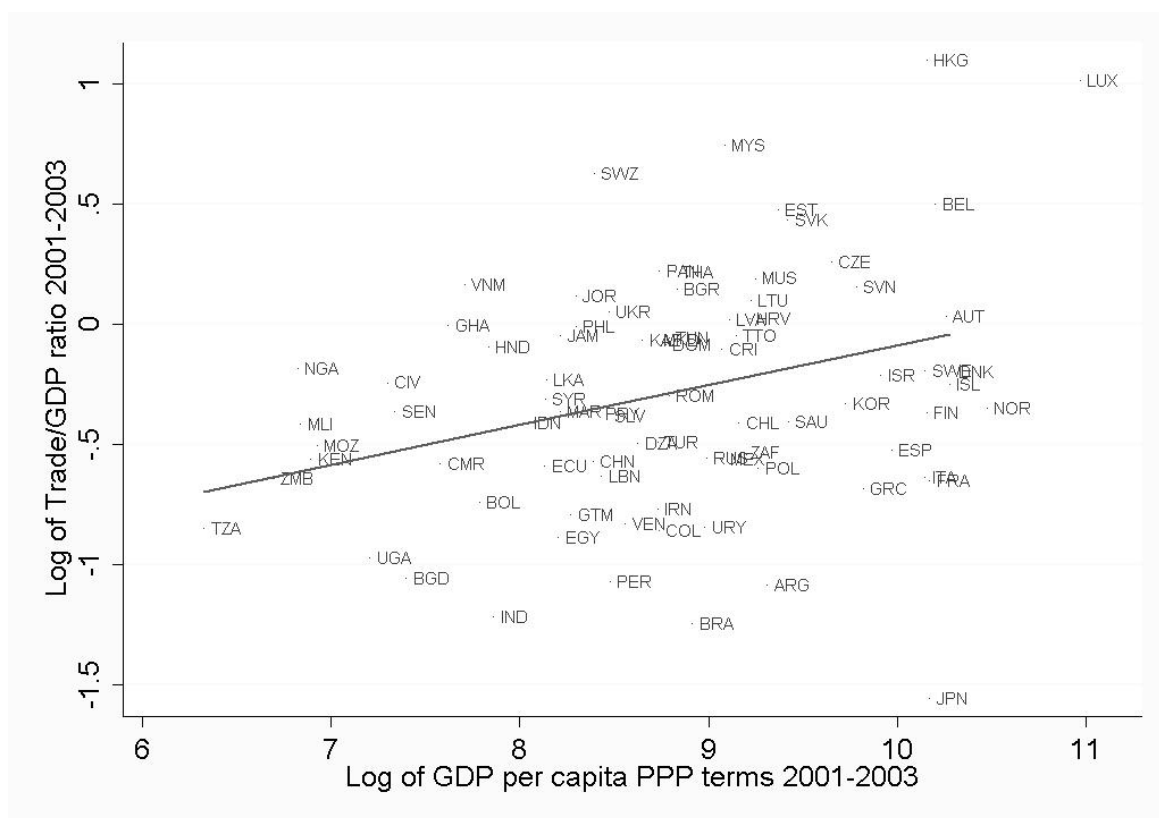


Figure 3: Average GDP per capita vs. trade/GDP ratio in 2001-2003.

Variables in logs, GDP in PPP terms.

Source: WDI database, World Bank.

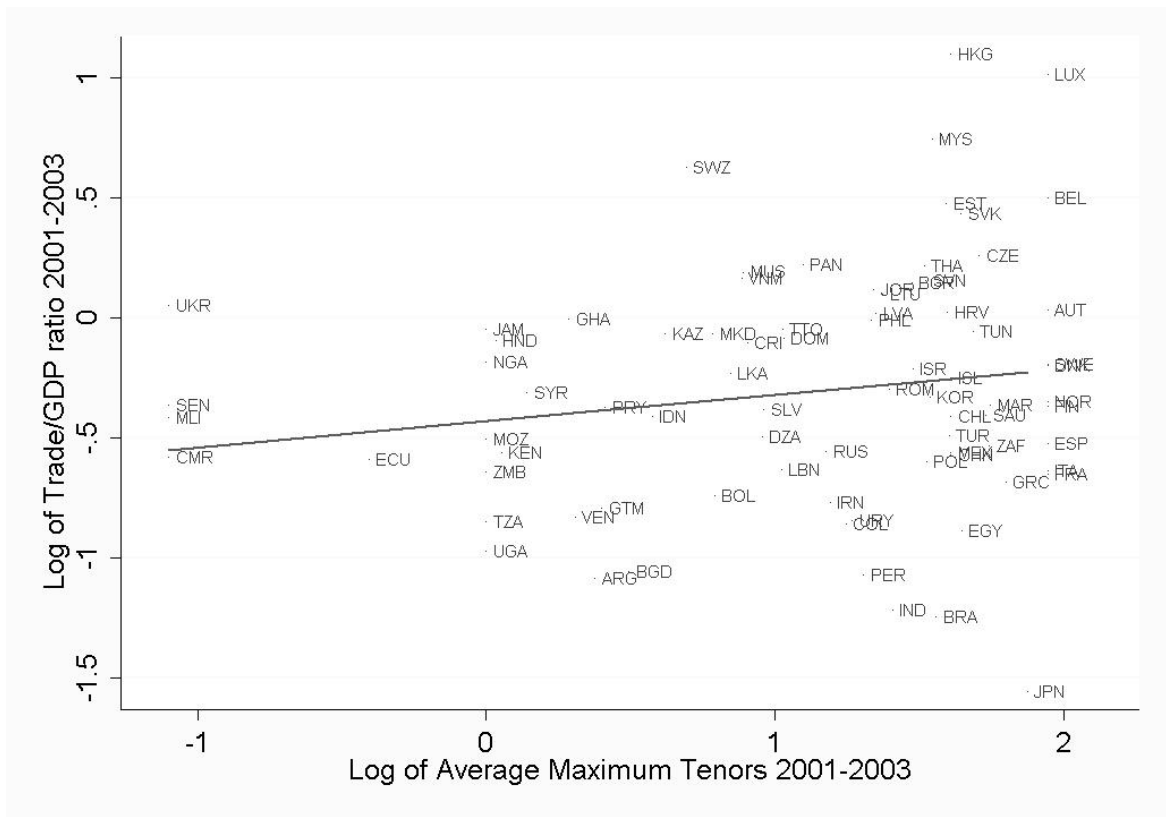


Figure 4: Average maximum tenors for forfaiting contracts vs. trade/GDP ratio 2001-2003.

Variables in logs, tenors in years.

Data from 5 agencies (NedBank, Standard Bank London, WestLB Forfaiting, Credit Lyonnais Forfaiting, Hungarian International Trade Finance) - horizontal axis and average log of trade per GDP ratio in 2001-2003. Source: Tenors - Trade Finance, openness - WDI database, World Bank.

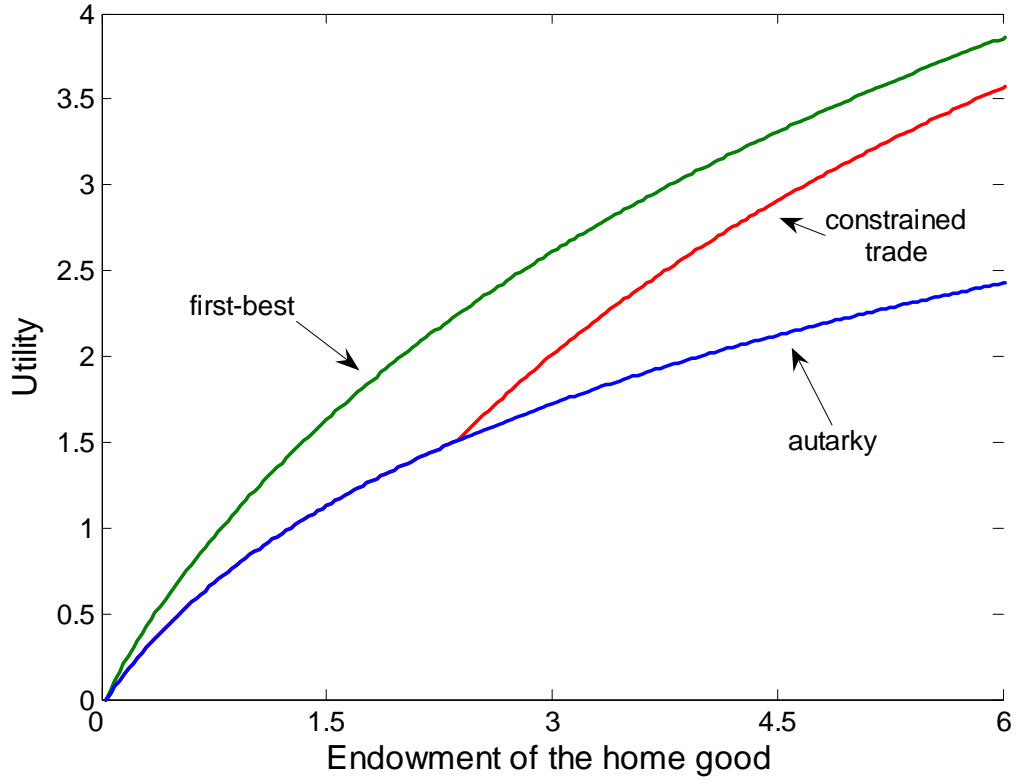


Figure 5: Simulation results, endowment economy.

Value function iterations.

Endowments are plotted on the horizontal axis, utility on the vertical one.

Parameter values: $u(c_t^x, c_t^y) = \ln(c_t^x + 1) + \ln(c_t^y + 1)$, $\beta = 0.2$, $p = 1.5$.

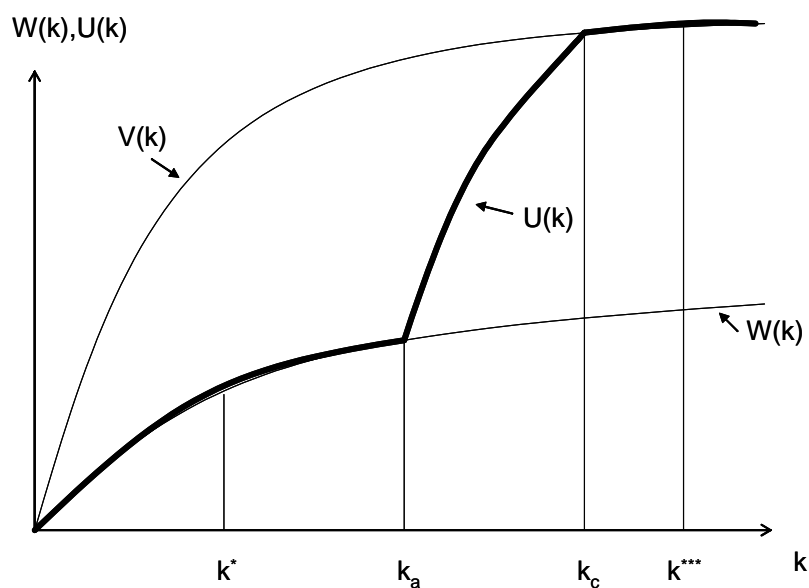


Figure 6: An example of hypothetical value functions.

- 1) Line labeled $V(k)$ denotes the value function of the unconstrained problem.
- 2) Line $W(k)$ denotes the value function of the problem in autarky.
- 3) Line $U(k)$ denotes the value function of the constrained problem.

The points k^* and k^{***} are steady states with no trade and unconstrained trade respectively.

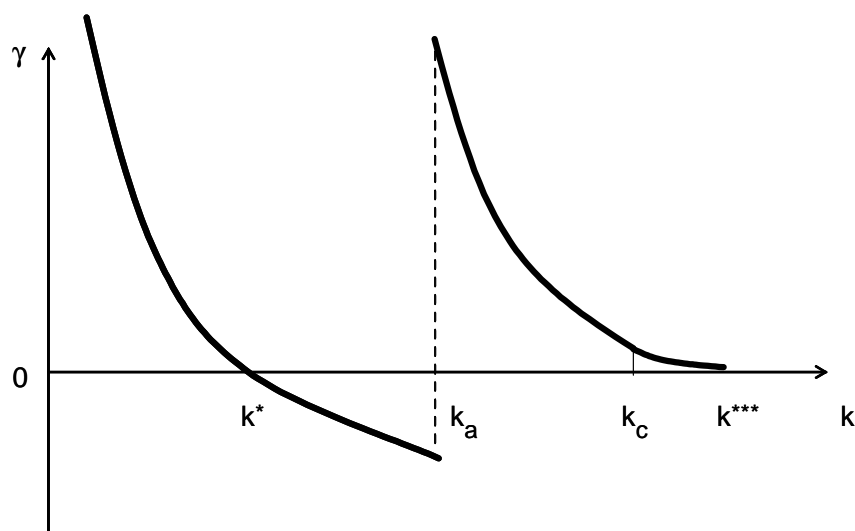


Figure 7: Possible growth rates (γ) in the economy with constraints associated with the example of the value function in Figure 6.

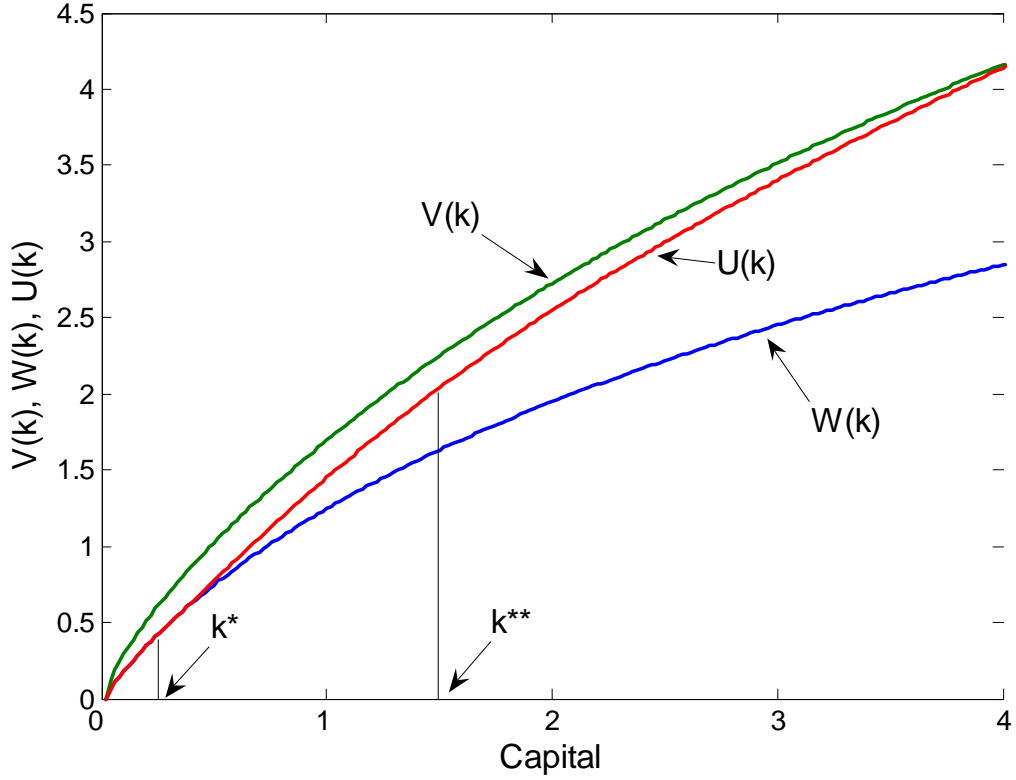


Figure 8: Simulation results, production economy.

Value function iterations.

Parameter values: $u(c_t^x, c_t^y) = \ln(c_t^x + 1) + \ln(c_t^y + 1)$, $f(k) = k^\alpha$,
 $g(I^x, I^y) = I^x + I^y$, $\beta = 0.55$, $p = 1.3$, $\alpha = 0.9$, $\delta = 0.25$.

There are two steady states at k^* (autarky) and k^{**} (constrained trade with the outside world).

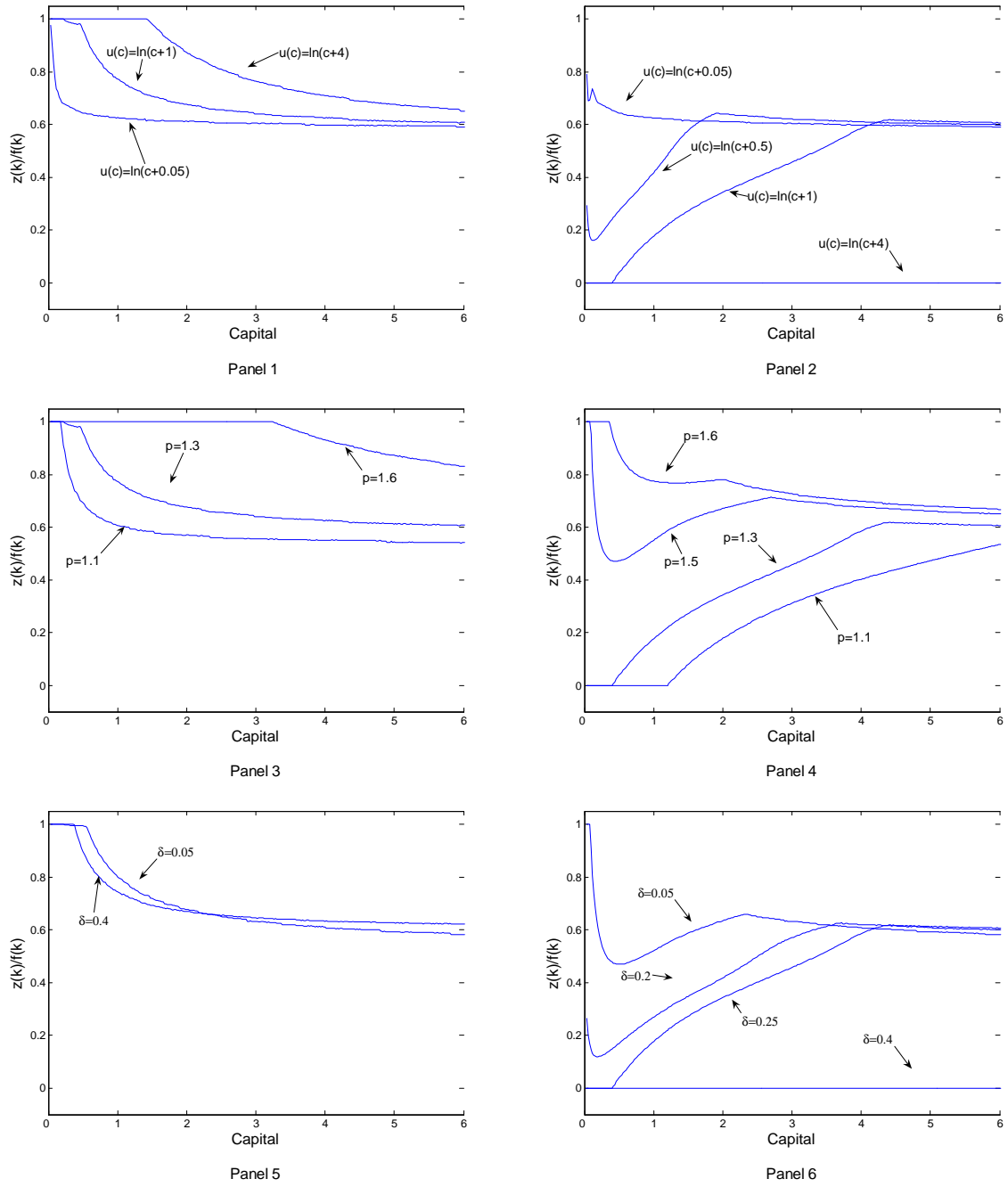


Figure 9: Comparative statics, example with multiple equilibria.

Capital vs. trade/production ratio.

Changes in the concavity of the period component function (panels 1-2), prices p (panel 3-4) and depreciation rates δ (panels 5-6).

Base specification: $u(c^x, c^y) = \ln(c^x + 1) + \ln(c^y + 1)$, $\beta = 0.55$, $\delta = 0.25$, $p = 1.3$, $\alpha = 0.9$.

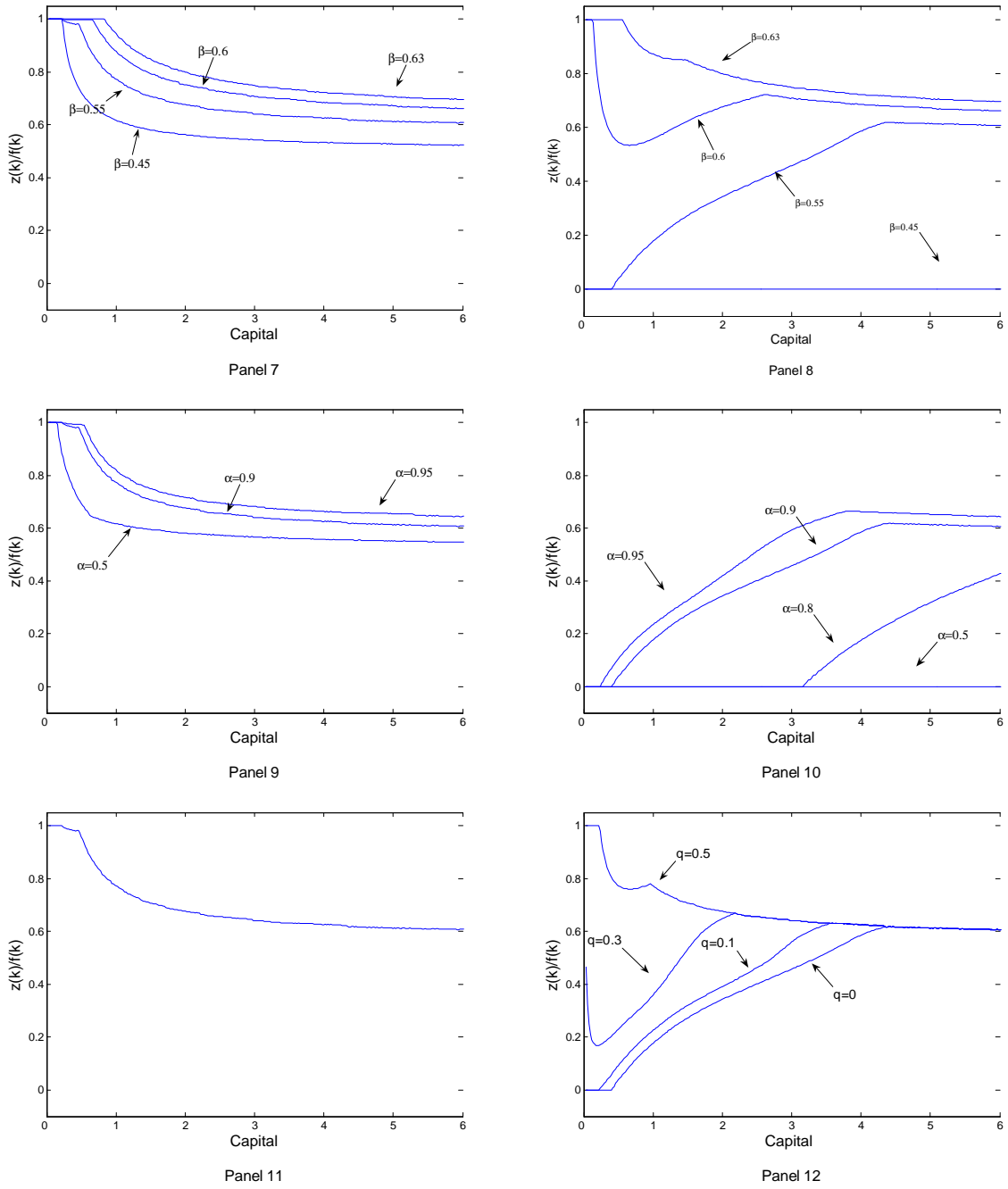


Figure 10: Comparative statics, example with multiple equilibria.

Capital vs. trade/production ratio.

Changes in discount factors (panels 7-8), capital intensity (panels 9-10) and rate of contract enforcement (panels 11-12).

Base specification: $u(c^x, c^y) = \ln(c^x + 1) + \ln(c^y + 1)$, $\beta = 0.55$, $\delta = 0.25$, $p = 1.3$, $\alpha = 0.9$.

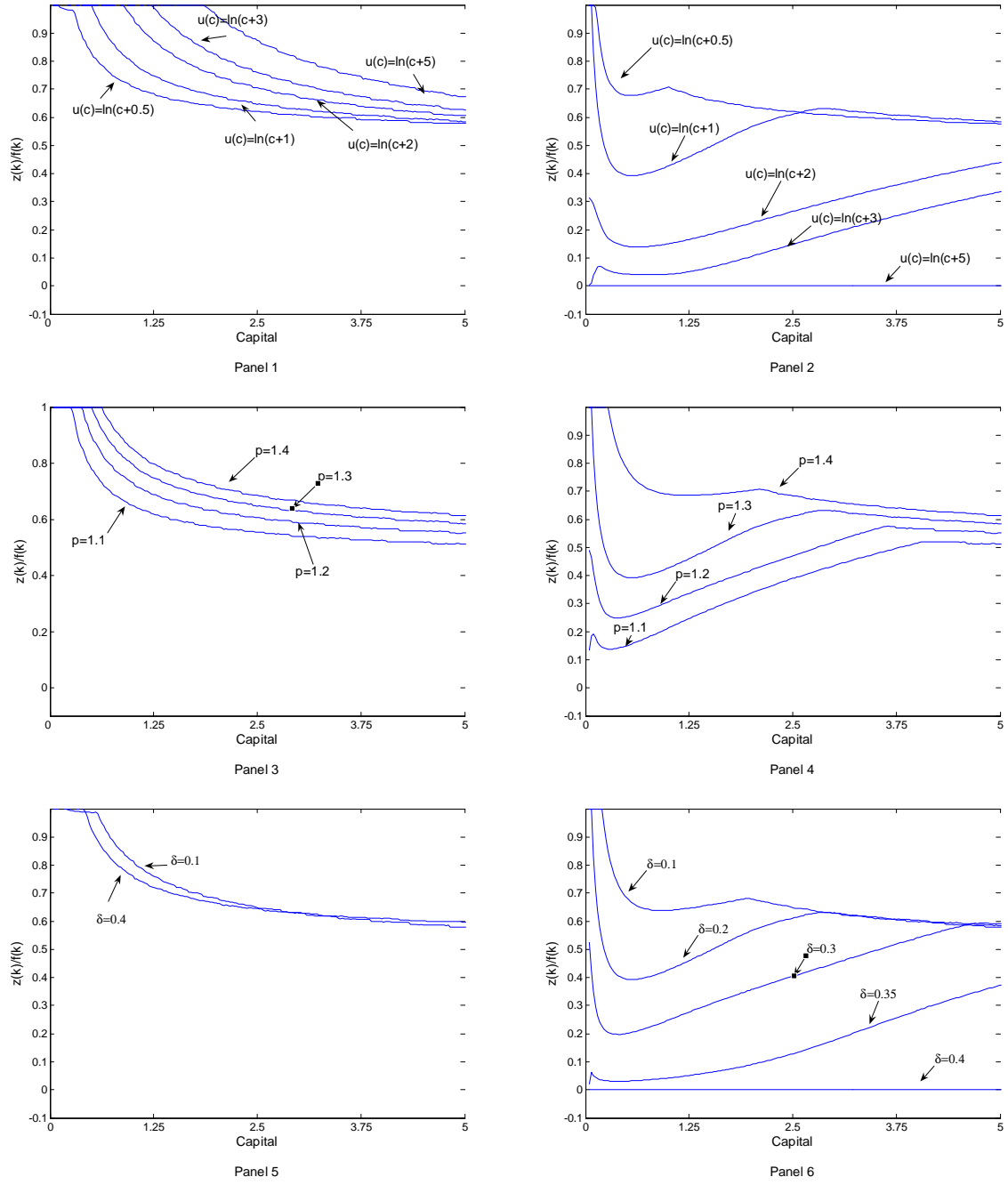


Figure 11: Comparative statics, example with no multiple equilibria.

Capital vs. trade/production ratio.

Changes in the concavity of the period component function (panels 1-2), prices p (panel 3-4) and depreciation rates δ (panels 5-6).

Base specification unless noted: $u(c^x, c^y) = \ln(c^x + 1) + \ln(c^y + 1)$, $\beta = 0.6$, $\delta = 0.2$, $p = 1.3$, $\alpha = 0.8$.

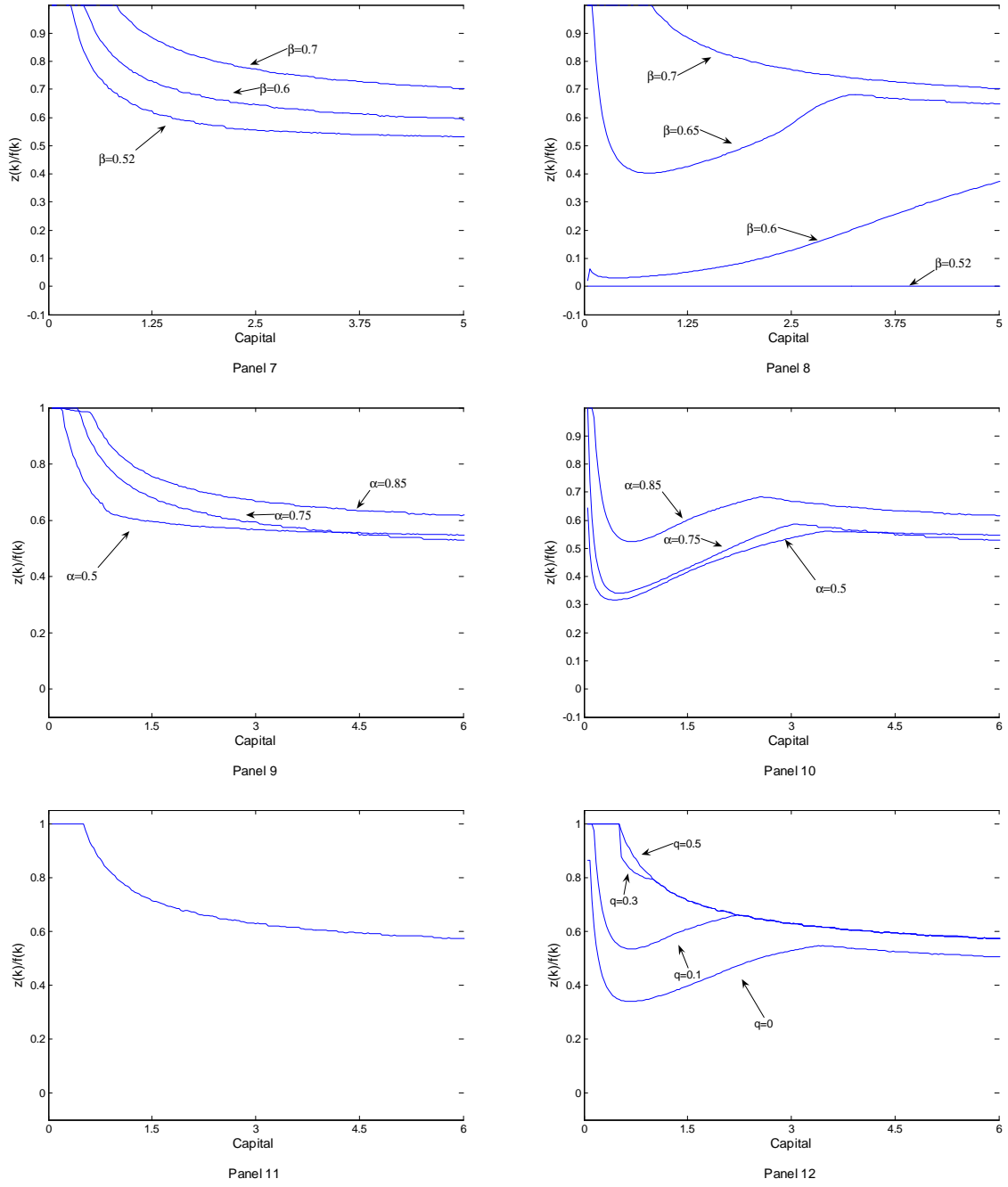


Figure 12: Comparative statics, example with no multiple equilibria.

Capital vs. trade/production ratio.

Changes in discount factors (panels 7-8), capital intensity (panels 9-10) and rate of contract enforcement (panels 11-12).

Base specification unless noted: $u(c^x, c^y) = \ln(c^x + 1) + \ln(c^y + 1)$, $\beta = 0.6$, $\delta = 0.2$, $p = 1.3$, $\alpha = 0.8$.

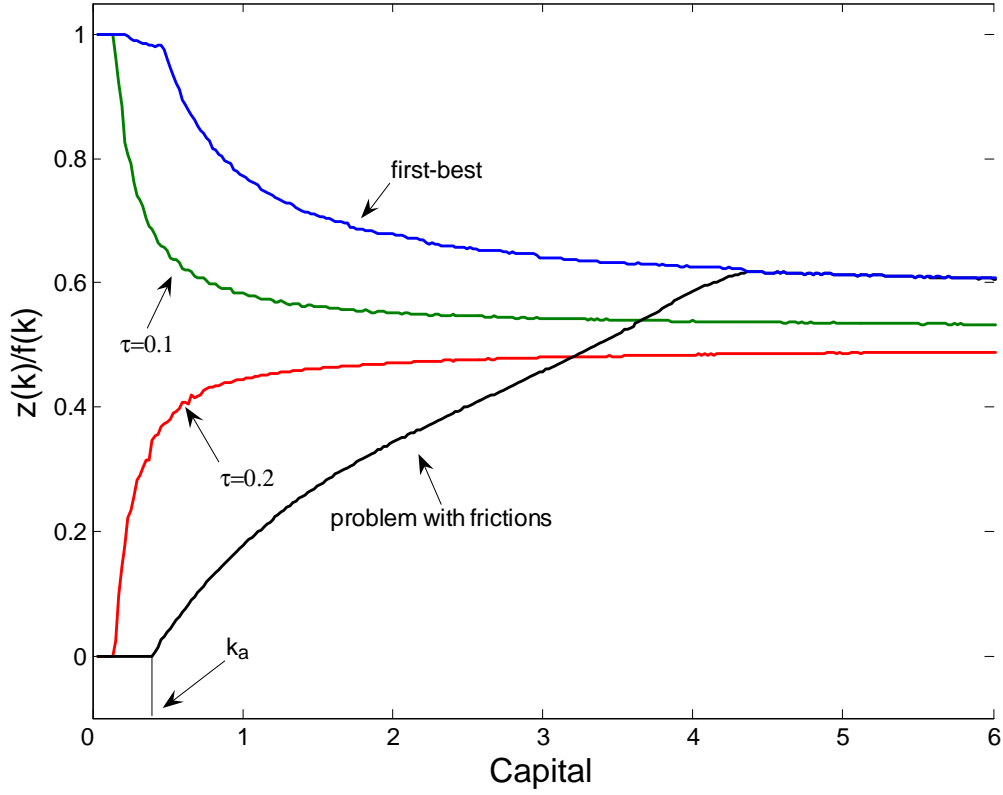


Figure 13: Simulation results, production economy.

Capital vs. trade/production ratio.

Comparison between allocations in Problem 2, Problem 1 and Problem 1 with trade costs.

Parameter values: $u(c_t^x, c_t^y) = \ln(c_t^x + 1) + \ln(c_t^y + 1)$, $f(k) = k^\alpha$, $\beta = 0.55$, $p = 1.3$, $\alpha = 0.9$, $\delta = 0.25$. Trade cost values imposed $\tau = 0.1$ and $\tau = 0.2$.

Table 1: Explanation of variable coding

Name	Explanation
$\ln Ten_i$	logarithm of average tenor of importer
$\ln Ten_j$	logarithm of average tenor of exporter
$\ln II_i$	logarithm of Institutional Investor ranking (importer)
$\ln II_j$	logarithm of Institutional Investor ranking (exporter)
$\ln Y_i/Pop_i$	logarithm of GDP in PPP terms per capita (importer)
$\ln Y_j/Pop_j$	logarithm of GDP in PPP terms per capita (exporter)
$\ln Y_i$	logarithm of GDP in PPP terms (importer)
$\ln Y_j$	logarithm of GDP in PPP terms (exporter)
$\ln Area_i$	logarithm of the area of the importer
$\ln Area_j$	logarithm of the area of the exporter
$\ln Lat_i Lat_j$	logarithm of the product of the distance from the equator
$\ln Dist_{ij}$	logarithm of distance between countries
FTA_{ij}	an FTA between countries in the dyad (0,1)
$\ln MFN_i MFN_j$	logarithm of the product of a simple average of applied MFN tariffs
$Contig_{ij}$	countries in the dyad share a border (0,1)
$Com_Lang_Off_{ij}$	countries have same official language (0,1)
$Com_Lang_Eth_{ij}$	countries have same ethnic language (0,1)
$ComCol_{ij}$	countries had a common colonizer (0,1)
$SameCtry_{ij}$	countries belonged to the same country in XX century (0,1)
$LandlockNum_{ij}$	number of landlocked countries in the dyad (0, 1, 2)
$IslandNum_{ij}$	number of islands in the dyad (0, 1, 2)
$Time$	time period

Table 2: Gravity equation estimation results

Dependent variable: ln(Imports/ $Y_i Y_j$)	Between	Between (IV)	Fixed effects	Between
ln Ten_i	.157*** (.094)	.409* (.148)	.157** (.071)	
ln Ten_j	.018 (.094)	.218 (.15)	.027 (.071)	
ln II_i				.446* (.161)
ln II_j				.72* (.161)
ln Y_i/Pop_i	.237* (.056)	.186** (.078)	2.525* (.942)	.132*** (.072)
ln Y_j/Pop_j	.522* (.056)	.575* (.078)	-.501 (.946)	.264* (.072)
ln Y_i	-.09* (.027)	-.095* (.03)	-1.232 (.975)	-.096* (.027)
ln Y_j	.165* (.027)	.17* (.03)	-.133 (.986)	.126* (.027)
ln $Area_i$	-.042* (.017)	-.038** (.018)		-.033*** (.018)
ln $Area_j$	.029 (.017)	.018 (.018)		.046** (.018)
ln $Lat_i Lat_j$	.151 (.022)	.107* (.023)		.146* (.022)
ln $Dist_{ij}$	-1.189* (.038)	-1.111* (.042)		-1.212* (.038)
FTA_{ij}	1.337* (.214)	1.156* (.276)		1.321* (.213)
ln $MFN_i MFN_j$	-3.178* (.392)	-1.606* (.215)		-3.238* (.392)
$Contig_{ij}$	.612* (.175)	.567* (.193)		.61* (.179)
$Com_Lang_Off_{ij}$	.596* (.14)	.497* (.158)		.561* (.14)
$Com_Lang_Eth_{ij}$	.417* (.125)	.681* (.14)		.424* (.124)
$ComCol_{ij}$	1.00* (.112)	1.01* (.126)		.927* (.112)
$SameCtry_{ij}$	.934* (.233)	.86* (.256)		.669* (.242)
$LandlockNum_{ij}$	-.483* (.062)	-.408* (.069)		-.433* (.063)
$IslandNum_{ij}$	.082 (.051)	.161* (.054)		.102** (.051)
$Time$			.069* (.022)	
Observations	11175	9252	11175	10944
R^2	0.48	0.49	0.02	0.48

Standard deviations in parentheses. Symbols *, **, *** denote that the variable is significant at 1, 5 and 10 percent level. Variable codes in Table 1.